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Retention and Fading of Military Skills: Literature Review

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Executive Summary

The Canadian Forces (CF) trains in a wide variety of skills. For reasons of efficiency and economy, it is important to conduct no more refresher training than is necessary to keep performance at the desired skill level. The purpose of this contract is to obtain a survey of the scientific and technical literature on models of skill fading and tools for determining when refresher training is required. In particular, the literature review investigated models for predicting skill retention relevant to the military domain.

Skill retention can be defined as the maintenance or sustainment of skills as learned behaviors and procedures over long periods of time without practice (Schendel & Hagman, 1991). Degradation in performance can be observed because the perceptual, motor, and cognitive processes that underlie skilled performance decay or break-down or because the individual loses the ability to access or perform those processes.

Skill retention can be described by a power function relating level of performance to the retention interval between training and test. This function is negatively accelerated, meaning that performance declines most rapidly soon after learning then at an increasingly slow rate over time. The two parameters by which skill loss can be characterized are the slope of the curve, describing the rate of skill loss, and the asymptote, which describes the level at which performance levels out. The power function offers the most accurate description of retention for a range of tasks and materials.

This literature review examines eight factors demonstrated to affect skill retention:

- Retention Interval.
- Opportunity to practice.
- Degree of learning.
- Method of training.
- Similarity of training and performance environments.
- Type of task
- Method of testing.
- Individual differences.

The literature review then examines several classes of models for predicting skill retention. Subjective approaches involve some form of self-assessment of retention and/or need for refresher training on the part of trained individuals. These techniques can yield accurate estimates of retention but are often mistrusted. Qualitative approaches indicate categorically how skills fade over time in relation to certain key factors. These models, as they stand to date, do not solve the practical problems of predicting when proficiency of skills will decline below a criterion or when refresher training will be needed but they do offer approaches that may be developed into quantitative models in the future.

The most fully developed quantitative model of skill retention is the U.S. Army Research Institute's Users' Decision Aid (UDA) model. This model was developed specifically to provide quantitative predictions of skill retention for military tasks. The UDA model was based on empirical studies documenting factors that affect skill retention. ARI researchers selected the following factors related to the task because these can be conveniently and economically measured:

- Number of steps
- Whether steps must be performed in a set sequence
- Whether the task contains feedback that indicates the correct performance of steps
- Number of facts or information chunks that must be recalled
- Execution demands
- Whether the skill is cognitive or perceptual/motor
- Whether there are job and/or memory aids for the task
- The time limit of the task (if any)

The UDA was developed by an iterative process of determining the empirical relationship between the set of factors and observed retention of certain military skills and determining the best fitting function describing that relationship (Rose et al., 1985b):

1. Identify task dimensions most likely to be related to retention.
2. Convert task dimensions into rating scales, develop anchor points, and analytically assign weights to each point on the scales.
3. Assess each scale's reliability and validity by having several judges rate tasks on each scale.
4. Examine inter-rate agreement and correlation between task ratings and actual retention data.
5. Iterate these steps to develop a set of valid and reliable scales.

The UDA model was developed to form the basis of a decision aid tool to be used in predicting skill retention and the need for refresher training in military tasks. The UDA contains ten questions that raters answer based on the task summary and their knowledge of the task. Raters select the appropriate answer and note the scale value associated with the selected answer. When all ten questions have been answered, the raters compute the total of the scale values, which constitutes the task's retention score. Multiple raters review the ratings given to the task and resolve differences to produce a final, agreed-upon task retention score. Scores are interpreted in two Performance Prediction Tables that are used to convert the total retention score into a prediction of performance for the rated task.

The UDA is one of few approaches for which empirical research has been done to assess its applicability and practicality. The UDA has been demonstrated to be relatively easy to administer, although some training is needed to perform the ratings correctly and reliably. The UDA itself is low-cost and requires no special equipment. The UDA, however, has received empirical validation from just one study that reports a comparison between UDA predictions and actual retention data.

Other quantitative approaches involve determining empirical retention curves for tasks or using training, individual, and other task factors to predict retention. These approaches may offer useful concepts but require extensive effort to develop.

The literature review identifies a set of lessons learned and discusses five specific recommendations:

1. Validate the UDA for the CF.

2. Conduct research to determine what factors can be incorporated to increase the accuracy of predictions.
3. Develop self-assessment tools.
4. Determine the applicability of the Relapse Prevention Model to supervisory, administrative, and other related tasks.
5. Conduct studies to derive empirical retention curves for critical tasks.

Table of Contents

EXECUTIVE SUMMARY ..... **III**

TABLE OF CONTENTS ..... **VII**

1. INTRODUCTION **1**

1.1 BACKGROUND 1
1.2 CANADIAN FORCES TRAINING PHILOSOPHY 1
1.2.1 Military Approach to Training *1*
1.2.2 Training Cycle-General *1*
1.2.3 Land Force Training Standards *3*
1.2.4 Peacetime Restraints Affecting Training *5*

2. SCOPE AND GOALS **7**

2.1 SCOPE OF THE LITERATURE REVIEW 7
2.2 APPROACH 8
2.3 METHOD 8
2.3.1 Develop Systematization Framework *8*
2.3.2 SME Review *9*
2.3.3 Search Literature *10*
2.3.4 Review Selected Articles *10*
2.3.5 Generate Survey of Literature and Lessons Learned *10*
2.4 TASKS 10
2.5 ACRONYMS 11

3. NATURE OF SKILLS, TASKS, AND TRAINING **13**

3.1 SKILLS AND SKILL FADING 13
3.1.1 Kinds of Skills *13*
3.1.2 Stages of Skill Development *13*
3.1.3 Defining Skill Retention *14*
3.1.4 Relation of Acquisition and Retention *15*
3.1.5 Empirical Studies of Skill Retention *15*
3.2 MILITARY TASKS 17
3.2.1 Individual Battle Tasks *18*
3.2.2 Occupation Specific Battle Tasks *18*
3.2.3 Collective Battle Tasks *19*
3.3 MILITARY TRAINING 19
3.3.1 Theories of Training *19*
3.3.2 Training Outcomes *20*
3.3.3 Training Implications of Expertise *22*

4. PREDICTING MILITARY TASK RETENTION **23**

4.1 FACTORS AFFECTING SKILL RETENTION 23
4.1.1 Retention Interval *24*
4.1.2 Opportunity to Practice *25*
4.1.3 Degree of Learning *26*
4.1.4 Method of Training *27*
4.1.5 Similarity of Training and Performance Environments *29*
4.1.6 Type of Task *29*
4.1.7 Method of Testing *30*

4.1.8 Individual Differences ... *30*
4.2 TRANSFER AND RETENTION OF SKILLS ... 31
4.3 SUBJECTIVE APPROACHES ... 31
4.3.1 Meta-Cognition and Self-Assessment ... *31*
4.3.2 Refresher Training Estimates ... *32*
4.3.3 Applicability and Practicality of Subjective Approaches ... *33*
4.4 QUALITATIVE APPROACHES ... 33
4.4.1 Training Criteria ... *33*
4.4.2 Relapse Prevention Model ... *35*
4.4.3 Model of Job Performance Determinants ... *38*
4.4.4 Applicability and Practicality ... *39*
4.5 THE ARI MODEL OF SKILL RETENTION ... 40
4.5.1 Theoretical Bases ... *40*
4.5.2 Development of the Model ... *42*
4.5.3 The UDA Decision Aid ... *44*
4.5.4 Empirical Evaluation ... *46*
4.5.5 Applicability and Practicality ... *47*
4.6 OTHER QUANTITATIVE APPROACHES ... 49
4.6.1 Correlational Approaches ... *50*
4.6.2 Applicability and Practicality ... *52*

5. IMPROVING SKILL RETENTION AND REACQUISITION ... 54

5.1 EFFECTS OF TRAINING TECHNOLOGIES ... 54
5.2 MILITARY WORK ENVIRONMENT ... 55
5.3 STRATEGIES FOR SUSTAINING READINESS ... 56

6. DISCUSSION ... 59

6.1 LESSONS LEARNED ... 59
6.2 RECOMMENDATIONS ... 62

REFERENCES ... 65

1. Introduction

1.1 Background

The Canadian Forces (CF) trains in a wide variety of skills, ranging from perceptual-motor skills, such as rifle marksmanship, to predominantly cognitive skills, such as command and control. Initial training raises performance to a criterion level, then refresher training is conducted periodically to maintain performance at or above criterion. For reasons of efficiency and economy, it is important to conduct no more refresher training than is necessary to keep performance at the desired skill level. The purpose of this contract is to obtain a survey of the scientific and technical literature on models of skill fading and tools for determining when refresher training is required.

1.2 Canadian Forces Training Philosophy

The December 1994 Defence White Paper confirmed the need for Canada to maintain multi-purpose, combat-capable sea, land and air forces to protect Canada and to project Canada's interests and values abroad. In order to maintain these multi-purpose forces, the Canadian Army, Navy and Airforce require "needs-trained" personnel.

In peacetime, training is the most important activity for the Canadian Forces (Atkinson, 1995), where training focuses on providing general purpose combat forces that allow Canada to fight and win in battle if necessary. It is also the view of the Canadian Forces that training to develop a general purpose combat capability meets the need established by the United Nations (UN) for military peacekeeping. Thus, it is the training philosophy of the Canadian Forces that the best training for the spectrum of conflict (conventional warfare to peacekeeping) pertains to basic skills specific to classification.

Standards drive training to ensure that military personnel are physically fit, capable, and can form the basis of effective units. Standards provide a measurable reference by which the CF can compare, evaluate, and identify deficiencies. For the Land Force, the Army Systems Approach to Training (ASAT) establishes the means by which it can measure performance, correct deficiencies, and maximize efficiencies.

1.2.1 Military Approach to Training

It is necessary for all personnel to be trained in the basic military skills before advancing to collective and combined training. If a deficiency is identified during initial evaluation, the individual must rectify that deficiency before he/she can operate effectively as part of a unit. Commanders are tasked to ensure intensive refresher training is conducted to ensure the soldier quickly reach the required standard. Should someone fail to reach the standards following this intensive refresher training period, more detailed training should be initiated.

1.2.2 Training Cycle-General

Training in the CF is progressively planned and can be divided into basic, individual and collective categories.

1.2.2.1 Basic Training

The basic training portion is covered by recruit courses and gives military personnel grounding in basic military skills to prepare them for the more advanced training. During basic training army soldiers are taught to never lose sight of the fact that their basic function is to be ready at short notice to engage an enemy. Since all military personnel must be prepared to defend themselves, it follows that regardless of their classification or occupation, all must reach a reasonable standard of individual combat effectiveness.

Figure 1.1: Recruit Firing the C7A1 Rifle

1.2.2.2 Individual Training

Military personnel must master basic military skills, built upon those learned during recruit training, before they can become successful members of a team, whether or not they are in a combat unit. Individual training comprises three parts:

a. General military training (GMT),
b. Leadership training, and
c. Technical/trades training.

The individual training phase is designed to mould individuals for the first specific position they will assume in a unit. In addition to GMT and trades training, there is a program to gradually develop the soldier's professional and personal qualities, which include courage, a sense of responsibility, endurance, alertness, inquisitiveness, discipline, loyalty, and leadership. On completion of the individual phase of training military personnel will still not be fully trained. They will, however, have learned a number of important military skills and are ready to join their unit as a member of a crew, section, or team.

Figure 1.2: Infantryman Firing the C9LMG

1.2.2.3 Collective Training

Collective training ultimately includes the grouping of all the combat, combat support, combat service support, air and other services on a formation level exercise. It is the culmination of the training cycle. Collective training in principle covers all units in the formation and must be progressive, starting with the sub-sub-unit and continuing upwards to unit and formation exercises. Under these conditions, operational training can be closely supervised and it will follow a logical progression. Several stages of training can however, be done concurrently. Training exercises must replicate, as closely as possible, real battle conditions.

1.2.3 Land Force Training Standards

Personnel receive their training from three areas: from Canadian Forces (CF) or environmental courses; from annual refresher training; and for those participating in peacekeeping operations, pre-deployment training. The Land Force's general purpose combat military training is based a series of standards:

a) Individual Battle Task Standards (IBTS)
b) Combined Arms Battle Task Standards
   - Brigade Group Battle Task Standards
   - Combat Team Battle Task Standards
   - Corps Battle Task Standards

All military personnel in the Land Force train to the Individual Battle Task Standards. This ensures a common standard for personnel of all trades or environments while employed on Land Force Bases and Units. Brigade Group and Combat Team Battle Task Standards insure that units and formations can perform to a common standard. Corps Battle task Standards focus on specific Corps tasks, e.g. infantry C7A1 rifle marksmanship. Every unit in the Land Force conducts annual refresher training and tests each soldier, sailor, airman or airwomen posted in its establishment on the Individual Battle Task Standards. Additionally all land units train and are evaluated against their Corps, Battle Group and Combat Team Battle task Standards.

Figure 1.3: Leopard C1 Crews During Armour Corps Gunnery Evaluation

Achievement of the Battle Task Standards are required prior to deploying on operations. However, it is not possible to maintain all Army personnel at this level of operational preparedness. Some units will require higher levels of preparedness than others based on assigned tasks, missions, and roles. It is a Commander's responsibility to ensure that resources are available to these units to meet these higher levels of preparedness. These same resources will also determine the level of preparedness that can be reasonably expected of certain units and individuals. It is understood that given limitations in ammunition, time, or other resources, certain Battle Task Standards will not be met by all units and personnel. There remains, however, a requirement to ensure the principle components of these Battle Tasks are evaluated so as to provide a foundation on which training can be built, in order to meet the standards. The IBTS programme provides this foundation and will involve yearly evaluation by means of a Tests of Elementary Training (TsOET) for the Battle Tasks. Successful completion of the TsOETs will be necessary for personnel reporting for pre-deployment training.

The three principles governing the ASAT are performance, systems approach, and maximum efficiency. Using these principles, the following approach to Battle Task evaluation should be followed:

a) **Performance**. All tasks will be performance-oriented to a logical conclusion (application). The evaluation of all tasks will be oriented to the operational requirement.
b) **System Approach**. All tasks will be constantly monitored and compared to operational, doctrine, and national goals and their effectiveness evaluated. Feedback through operational reporting and training validation will be conducted.
c) **Maximum Efficiency**. There is no denying the fiscal realities of peace. Training is a costly exercise to rectify deficiencies. If there is no deficiency, there is no need to expend limited resources and time correcting something that is not deficient. Therefore, all tasks in this regulation should be tested prior to initiating refresher training. If a deficiency is identified (i.e. The standard is not achieved), only then should a soldier receive refresher

training to correct the deficiency. Correct targeting of high failure risk populations is required to ensure max efficiency is attained.

1.2.4 Peacetime Restraints Affecting Training

A number of restraints affect the quality and quantity of training possible.

1.2.4.1 Budgetary Considerations

Budgetary restraints have now become a fact of life for all military trainers. The costs pertinent to equipment, ammunition, transportation and logistic requirements must be carefully assessed before any training is undertaken.

Figure 1.4: Crew Firing the ERYX Anti-Tank Missile. Note Each Training Missile Costs $13,000

1.2.4.2 Organizational Considerations

In peacetime, war establishments are usually restricted. Commanders must adapt appropriately when this occurs. For example, there may be a battery missing in an artillery regiment, a squadron in an armoured regiment, or a service support unit may lack a particular field capability. To offset manpower deficiencies, the employment of the reserves and militia, either as individuals or as formed organizations, is always be considered by the regular force.

1.2.4.3 Equipment Considerations

Equipment in peacetime is not always available and often has to be pooled. During the annual training cycle it is often necessary for units to provide equipment for demonstrations or for other formations which were not included in the original training program.

1.2.4.4 Ammunition, Explosives and Pyrotechnics

Emphasis is placed on the creation of realism to stimulate interest on all training exercises. One of the many characteristics of battle is noise. Until soldiers are accustomed to the crack and whine of bullets and shells, it is difficult for them to think calmly under that stress. The extent to which such noise can be produced in training depends almost entirely upon the training ammunition, pyrotechnics, and explosives available. Unfortunately supplies are usually small, and an atmosphere resembling battle is difficult to achieve. Operational commanders are therefore required to economize and determine when the best training value can be gained from the limited resources.

1.2.4.5 Transportation and Logistics Considerations

The movement of military equipment is expensive. Thus, it may be desirable to move a few priority items of equipment to an exercise area and arrange the loan of equipment from other units in the vicinity.

1.2.4.6 Air Considerations

Air transport is generally in short supply in peacetime and demands for it must be made well in advance of planned exercises.

1.2.4.7 Training Restrictions

Training is also subject to a number of peacetime limitations, such as restrictions on digging, cutting trees for camouflage, movement off roads, or running vehicles at night without lights.

2. Scope and Goals

2.1 Scope of the Literature Review

Training in a large array of skills creates a problem for a professional organization such as the CF. Because forgetting can occur over any time period without practice (e.g., Goldberg & O'Rourke, 1989; Hagman & Rose, 1983; Schendel & Hagman, 1982), the skills of those trained will gradually degrade, eventually to the point at which skills do not meet required levels of proficiency. This is true for any training organization and many others have considered the issues surrounding it (e.g., Wisher, Sabol, & Ellis, 1999):

- How quickly does forgetting occur for different kinds of skills?
- Are some individuals more likely to forget than others?
- What instructional strategies are effective in reducing forgetting?
- How difficult will it be to reacquire forgotten skills?

The first of these questions is central and this literature review will address it in detail. The primary goal of this literature review is to identify and review models for predicting skill retention that can be applied in the military domain. A secondary goal is to identify the fundamental factors that affect skill retention and will affect the applicability of models of skill retention.

A literature review examining skill fading must consider a variety of skills. In particular, we will systematically examine factors affecting training and skill retention with respect to the different kinds of skills relevant to the CF. Techniques that promote good retention for one type of skill may not be suitable for another type of skill. Consequently, it is important to determine a framework for interpreting the literature in a way meaningful to the skill requirements of the CF.

This literature review is not intended to be a comprehensive survey of the theoretical and empirical research surrounding skill acquisition and retention. Rather, it will seek to address several core issues of relevance to the prediction of skill retention.

First, the literature review is limited to questions of skill retention. For this reason, we will not explore skill acquisition, transfer of skills, or other related topics, except as they affect skill retention.

Second, the review will focus on models for predicting skill retention. The goal of the project is to determine an accurate means of determining when refresher training will be needed to sustain military tasks. Consequently, there is a need for detailed quantitative models of skill retention. We will not ignore qualitative models and other approaches to estimating skill retention, but will emphasize the potential to provide predictions usable by trainers and commanders to determine refresher training needs. As part of the review we will examine:

- The type of skills to which various models apply.
- Empirical support for the predictive validity of models.
- The information required by models.
- The practicality of use of models.
- The cost of use of models.

Although the focus of the review is on models of skill retention, we will conduct a thorough review of factors that affect skill retention. Knowledge of these factors is crucial to evaluation of existing models and development of future models.

Finally, the literature review is focused on skills relevant to the military domain. For this reason we excluded research pertaining to sports psychology. Many military tasks involve motor and perceptual skills but a large number are highly cognitive, requiring complex decision making and reasoning. We will discuss literature pertaining to retention of all kinds of skills, but will emphasize research directly examining retention of skills in the military context.

2.2 Approach

Despite the broad skill-base of the CF, the focus of the literature review must be on those skills and training factors that pertain strongly to the military. Research on learning, training, and skill retention in other domains, such as business and education, can be relevant but must be interpreted with respect to the skill requirements of the CF. Thus, we reviewed the literature with respect to the basic, specialized, and command skills relevant to the CF.

Of particular relevance to the CF are factors specific to the military domain, such as career paths, posting cycles, and so on. These factors affect training and retention but are unlikely to have been considered in the general literature on skills. Thus, we made special effort to survey military scientific research to determine how these factors might affect skill retention.

Our review has not concentrated exclusively on any single service but addressed issues of skill retention common to the Army, Navy, and Air Force. Although some differences in skills and training needs likely exist across the different services, there are many commonalties, so that lessons learned for one service are applicable for the others. To explore the results of the literature review, we developed three practical examples of skill learning and retention directly relevant to the CF. The examples illustrated the factors affecting skill retention for basic, specialized, and command skills common to the three services. This technique was used to highlight practical results as well as ensure relevance. The examples were developed with the input of Subject Matter Experts (SMEs) from the CF.

We adopted a practical focus in our review and interpretation of the scientific literature. The ultimate goal was to develop training design recommendations to promote skill retention for the CF. We surveyed the applied science literature to identify guidelines. In addition, we surveyed the basic science literature with the aim of identifying theories and empirical results that indicate practical lessons learned.

We also adopted a focus on skill retention. Research on skill acquisition, knowledge representation, and similar issues was relevant to the literature review and we gave that due consideration. However, the goal of the review was to identify ways for determining optimal training and refresher training programs. Thus, all issues were reviewed as they relate to the issue of skill retention.

2.3 Method

A literature review is a systematic study and organization of a large body of scientific research. The key to success, then, is to develop a framework for interpreting the literature and generating clear and useful insights, lessons learned, and recommendations for future research and practice. We followed a number of steps to complete the literature review.

2.3.1 Develop Systematization Framework

The first step of the literature review is to develop a framework for organizing and interpreting empirical results and theories of skill retention. The framework is a system for classifying literature in a way meaningful to the CF. Such a framework is needed to make sense of the literature and to relate results to the specific training and skill retention needs of the CF. The framework will identify the fundamental factors that affect skill acquisition and retention as it relates to the military domain. It is likely that different combinations of these factors will necessitate different approaches to training to yield optimal skill retention.

We were able to identify two fundamental factors relevant to the CF (see Table 1). The first was the *type of skill* under consideration. This factor likely exerts a great deal of influence over retention in itself. In addition, however, this factor almost certainly interacts with numerous other factors (e.g., training type, frequency of refresher training, etc.) to determine skill retention. Two levels of type of skill are commonly distinguished (e.g., Anderson, 1990); perceptual/motor and cognitive. The former refers to tasks that predominantly entail physical activities and/or basic perceptual activities, such as visual monitoring. The latter refer to the very broad range of tasks that entail decision making, memory, and reasoning activities

The second factor was the *military task domain.* This factor plays a role in determining the type of skills required as well as a number of factors that could potentially affect skill retention, such as complexity, frequency of training (due to availability and posting cycle issues), and available training resources. We were able to distinguish at least three levels of this factor; basic/general, specialized, and command. Basic/general tasks are those that are required or trained for a large proportion of the CF, whereas specialized tasks are required by a relatively small proportion. Specialized tasks are likely to be more complex and cognitive than basic tasks. Command tasks are highly cognitive but are distinguished here because they entail a distinctive set of skills drawn from a wide range of task domains (Bryant & Webb, 1999).

These two factors served as a *preliminary* systematization framework. This preliminary framework was evaluated and revised on the basis of feedback from SMEs and results of the literature search.

We then reviewed the literature in relation to the framework. Results of the literature review were classified with respect to the framework so that we could relate theories, models, and lessons learned to the goals and concerns of the CF.

Factor	Levels
Type of Skill	Perceptual/Motor Cognitive
Military Task Domain	Basic/General Specialized Command

Table 1.1 – Fundamental Factors Affecting Skill Retention

2.3.2 SME Review

The goal of the literature was to identify theories and lessons learned that are applicable to the CF. Consequently, an important step was to review military skills and training requirements with SMEs. The purpose of this review was to:

- Identify critical issues.
- Identify examples of relevant skills and training to be used to illustrate the results of the literature review.

- Prioritize the focus of the literature and limit its scope.
- Validate the systematization framework.

2.3.3 Search Literature

The first step in conducting the search of the literature was to identify relevant databases of scientific research. We surveyed databases for psychology, human factors, military, professional/business, and other related domains to compile a set of databases to search.

The next step was to generate a set of keywords based on experience and SME input. Keywords were organized in terms of the validated systematization framework to yield combinations of keywords that focused on the conceptual distinctions relevant to the goals of the literature search.

The prioritized set of keywords was applied to the databases to identify roughly 200 abstracts/titles. These were subjected to a brief review to establish the scope, level of detail, and currency of their content. Of these, we selected roughly 65 for detailed review and these became the basis of the literature review.

2.3.4 Review Selected Articles

Once we had selected the key articles, we conducted a thorough review of each article. The review:

- Identified factors and issues relevant to skill retention.
- Identified theories and models of skill acquisition and skill retention.
- Identified models, tools, and techniques of reducing skill fading.

2.3.5 Generate Survey of Literature and Lessons Learned

Based on the review of key articles, we generated an account of the major theories and models relevant to skill retention. The review allowed us to evaluate these theories based on scientific validity and applicability to the CF. Our literature survey:

- Developed a comprehensive list of factors promoting skill acquisition and skill retention.
- Developed a comprehensive list of tools and techniques that can be used to promote skill retention.
- Classified factors, theories, and techniques based on the systematization framework.

The literature survey provided a detailed account of the scientific literature. This survey was focused on the issues relevant to the goals of the CF (as developed through the review with SMEs).

The final step of the literature survey was to generate a set of design recommendations for military training. These recommendations were categorized by the systematization framework. Recommendations advanced practices and techniques that could improve the quality and efficiency of training efforts by the CF.

2.4 Tasks

As part of the project, we completed the following specific tasks:

- Start-up meeting.
- Determine and prioritize requirements.
- Review focus with SA and SMEs.
- Frame keyword search.

- Conduct preliminary search.
- Review findings of preliminary search and reframe.
- Conduct full search.
- Review titles and prioritize.
- Create an EndNote database of references.
- Obtain articles and add to the database.
- Review articles.
- Draft report.
- Review draft report with SA.
- Revise and submit final report.

2.5 Acronyms

AFOQT	Air Force Officer Qualifying Test
AFQT	Armed Forces Qualification Test
AFS	Air Force Specialty
ANOVA	Analysis of Variance
ARI	Army Research Institute
ASAT	Army Systems Approach to Training
ASVAB	Armed Services Vocational Aptitude Battery
BST	Basic Skills Trainer
CCS	Combat Service Support
CF	CF
COFT	Conduct-of-Fire Trainer
d	Effect Size
DK	Declarative Knowledge
EOMM	Ease-of-Movement Matrix
g	General Cognitive Ability
GIL	Graphical Instruction in LISP
GMT	General Military Training
IBTS	Individual Battle Task Standards
IRR	Individual Ready Reserve
M	Motivation
MOOTW	Military Operation Other Than War
MOS	Military Occupational Specialty
NTC	National Training Center
OOTW	Operation Other Than War
PC	Performance Component
PGTS	Precision Gunnery Training System
PKS	Procedural Knowledge and Skill
PRIME	Precision Range Integrated Maneuver Exercise
RRS	Readiness Reporting System
SAF	Semi-Autonomous Forces
SME	Subject Matter Expert
TsOET	Tests of Elementary Training
TSQ	Transfer of Skills Questionnaire
UDA	User's Decision Aid
UN	United Nations

U.S.	United States of America
USAREUR	U.S. Army Europe

3. Nature of Skills, Tasks, and Training

3.1 Skills and Skill Fading

3.1.1 Kinds of Skills

Skill can be defined in two ways. First, it is the achievement of some criterion level of performance at a task. Thus, a person who can perform a task is said to possess some level of skill and a person who performs the task well is said to possess expertise, or an extremely high level of skill. In practical terms, this definition is often of interest in the military because it describes capabilities of personnel.

In terms of understanding skill retention, however, a second definition is needed. Skill is any kind of learned procedure, problem solving technique, or sequence of steps, although researchers often concentrate on learned behaviors that depend upon motor processes (Schendel & Hagman, 1991). Thus, we can understand skills in terms of their underlying cognitive and motor representation and processes. We distinguish skills, which are acquired through formal training or experiential learning, from non-learned abilities or basic human capabilities.

Skills are goal-directed and organized in complex sets of skills that are used together in a work domain (e.g., Kraiger, Ford, & Salas, 1993). Thus, skills exist as meaningful cognitive structures or networks that guide behavior.

Just as there is a huge variety of tasks or jobs that people perform, there are a wide variety of skills that can be acquired. These range from motor and perceptual skills to cognitive skills to interpersonal and management skills. Training leads to acquisition of procedures, knowledge, and motivation or affective components (Kraiger et al., 1993). We should not focus exclusively on procedures because they require both information, in the form of knowledge and cognitive processes acquired to perform procedures, and attitudinal and motivational dispositions that support performance. Simply put, one cannot effectively perform a task without requisite knowledge or the will to do it.

Skills also rest upon basic information processing and decision making capabilities (Wisher, Sabol, & Ellis, 1999). Many military tasks, such as trouble-shooting and tactical command, involve working with large amounts of information in an ill-defined problem space. The procedures to follow in these cases are less well defined and necessarily involve many decision points.

3.1.2 Stages of Skill Development

A widely accepted theory of the development of expertise is Anderson's three-stage theory (Anderson, 1995). This theory describes the transitions in knowledge and skill level from novice to expert. It is a general model, meant to apply to cognitive and behavioural domains. Thus, it is, in principle, applicable to any kind of military task but should be validated for any specific application.

According to Anderson's model (See Anderson, 1995, Ch. 5), the first stage of skill acquisition is the *cognitive stage*. At this stage, the individual develops declarative knowledge of the task, including its rules, procedures, constraints, and so on. All of this knowledge is factual and explicitly stored in the declarative memory store (Tulving, 1983). To access this knowledge, the individual consciously recalls facts about the task and attempts to use them to guide performance. Thus, at this stage, there is little procedural knowledge and the individual must devote a great deal of mental effort to directing his or her actions.

The second stage is the *associative stage*. In this stage, the individual gradually notices and corrects errors in his or her declarative knowledge and strengthens the associations between cues and problem elements and the actions or steps needed to perform the task. Thus, the individual forms greater associative memory (e.g., if-then rules) that can be used to guide behaviour. Performance is still not based on true procedural knowledge but the stored associations allow for faster, less effortful performance.

The final stage is the *autonomous stage*. Here, the associative productions developed earlier become automatic. Knowledge is stored in procedural memory that can be accessed implicitly and without conscious effort (or very little). Performance is initiated in response to situational cues that determine which learned procedures should be called upon.

This theory is consistent with observations of increased automaticity and proceduralism with expertise in a variety of domains (Anderson & Fincham, 1994). However, to fully understand expertise in cognitive domains (those requiring decision making and reasoning), we must identify differences in the knowledge structures of experts and novices.

Experts have more comprehensive and better organized domain knowledge than novices (Lesgold, Rubinson, Feltovich, Glaser, Klopfer & Wang, 1988; Sternberg, 1996; Wiley, 1998). This is almost a tautology but it indicates two important processes of expertise acquisition, namely a) the identification of crucial concepts, cues, and procedures in the domain, and b) the organization of knowledge to facilitate rapid and accurate access to those concepts, cues, and procedures. Thus, as a person develops expertise, memory becomes specialized to recognize and retrieve appropriate responses to problems in that domain.

In addition to proceduralization, a process of schematization also occurs as one develops expertise. The expert creates mental frameworks that describe the kinds of problems encountered in the domain, the kinds of cues that indicate problems, and the kinds of solutions that can be applied. Anderson (1995) distinguishes between tactical and strategic learning. Tactical learning deals with the acquisition of skills and procedures, following the three stages of Anderson's model. Strategic learning refers to learning how to organize one's problem solving. Creating mental schemata to organize domain knowledge allows one to determine the best means to solve problems and quickly judge the applicability of solutions.

Anderson's theory implies that training should focus more on procedures than information. Because expertise involves acquiring sets of specific procedures, training can be enhanced by analyzing what those procedures are. Thus, a prerequisite to training is a thorough task analysis. The results of this analysis will be specific tasks and procedures that can be explicitly taught to novices. Such training will be especially effective if tasks are broken into components, each of which can be mastered more easily than the whole task in its entirety.

3.1.3 Defining Skill Retention

Before examining skill fading, we must clarify the concepts of skill retention and loss. In one sense, skill fading (or reduction of skill retention) is the measurable decrement in performance of a skill relative to a criterion. Ultimately, we are concerned with the levels of performance of tasks, on which this definition focuses. This definition, however, is simply the observable symptom of internal processes. Of greater concern is the maintenance or sustainment of skills as learned behaviors and procedures over long periods of time without practice (Schendel & Hagman, 1991).

There are, however, two general potential causes of performance degradation over time. Reduced performance may reflect some degradation of the perceptual, motor, and cognitive processes that underlie skilled performance. This could take the form of *decay* or break-down of the learned procedures. Reduced performance, however, could also reflect the *inability to perform* learned skills. In this case, the perceptual, motor, and cognitive processes of the learned skill may be completely intact but, for some reason, not usable by the individual.

This distinction is based on the long-standing distinction between availability and accessibility of human memory (Tulving & Pearlstone, 1966; Tulving, 1983). Observation of some decrement in performance does not necessarily indicate a change in the availability of a skill. Rather, it only indicates some loss of accessibility. Reduced accessibility may result from degradation of the learned skill but it may reflect factors or processes related to the retrieval and execution of the skill. This distinction is crucial because it has clear implications for the prediction and remediation of skill loss.

3.1.4 Relation of Acquisition and Retention

It is also important to consider the goals of training when examining retention. Typically, the main goal of training is to promote long-term performance in the real world. Much training, however, focuses on achieving high levels of performance in the training course. Training is the only opportunity that trainers have to affect and assess performance but performance in the training session is not itself the goal. An implicit assumption of most training courses is that procedures that enhance performance during training necessarily enhance long-term performance in the real world (Schmidt & Bjork, 1992).

This assumption, however, is not always true, as illustrated by experiments that demonstrate manipulations that maximize performance during training but lead to inferior long-term performance, or vice versa. Landauer & Bjork (1978), for example, observed that massed practice of a name-learning task yielded better performance during training than did spaced practice but worse performance on tests of long-term retention. In fact, introducing difficulties for learners in the form of variability in practice and feedback can enhance later performance (Schmidt & Bjork, 1993).

Acquisition and retention do not appear to be separable phenomena (Schmidt & Bjork, 1993). Given the goal of enhancing long-term performance, acquisition can only be measured in terms of retention. That is because performance during training is an imperfect predictor of long-term performance. Given the distinction between availability and accessibility, it is clear that good acquisition itself does not guarantee later performance. Transfer of skills learned in training to real world tasks depends on many factors outside the training environment, including individual and organizational issues (Kavanagh, Lance, O'Brien, Stennett, McMillen, & Solomonson, 1997).

3.1.5 Empirical Studies of Skill Retention

Before considering models for predicting skill retention, it is worth reviewing several basic empirical findings concerning the nature of skill retention. Decrements in performance can be described by a power function relating level of performance to the retention interval between training and test (e.g., Anderson, 1995; Wixted & Ebbesen, 1991)[1]:

$$d' = A \bullet T^{-b}$$

d' = measure of performance
A = asymptote of curve
b = slope of function

[1] The power function is often expressed in logarithmic form as Log(d') = A – b log T.

T = time

This function, illustrated in Figure 3.1, is negatively accelerated, meaning that performance declines most rapidly soon after learning then at an increasingly slow rate over time. The two parameters by which skill loss can be characterized are the slope of the curve, describing the rate of skill loss, and the asymptote, which describes the level at which performance levels out. Wixted and Ebbesen (1991) have observed that the power function offers the most accurate description of retention for a range of tasks and materials (see also Grant & Logan, 1993).

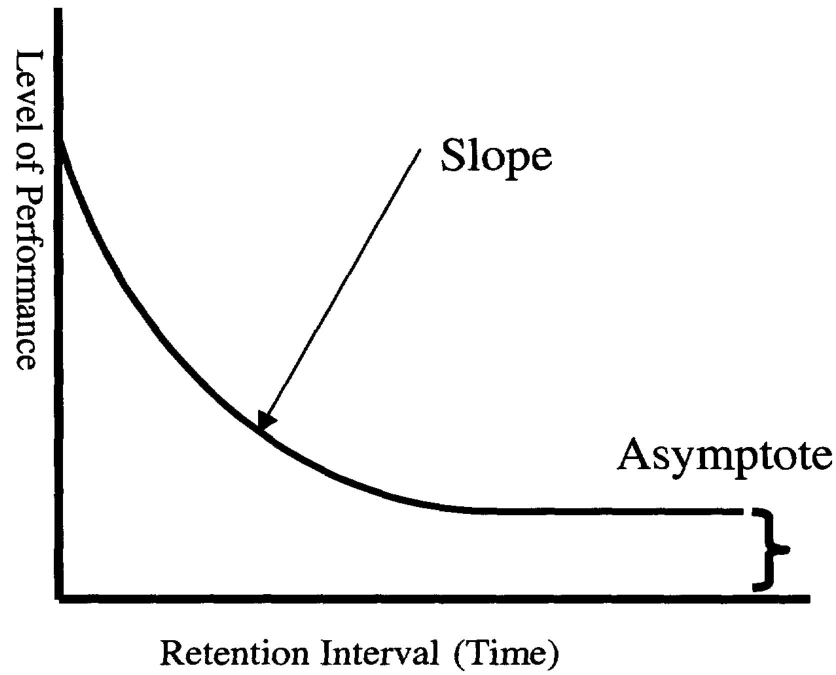

Figure 3.1 - Idealized Power Function Relating Retention Performance to Retention Interval

The nature of the skill loss function indicates that one can expect proportionately large degrees of skill loss after only moderate amounts of time. This has been confirmed in numerous studies examining retention of military tasks. In one example, Wisher, Sabol, Sukenik, and Kern (1991) examined skill loss by twenty thousand Individual Ready Reserve (IRR) soldiers mobilized by the U.S. Army for Operation Desert Storm. These soldiers had completed active service and were pretrained and experienced but had not been on active duty for some time. They had received no training while in the IRR. As expected, Wisher et al. (1991) found that soldiers from IRR call-up had markedly lower levels of skill performance and knowledge in a number of Military Occupational Specialties (MOS) than continuously active soldiers. Similarly, Burcham (1998) found that retention of Tactical Unmanned Vehicle tasks by soldiers showed rapid decline from two to twelve weeks, with the most severe decriment in performance coming at two weeks.

Another implication of the skill loss function is that different skills should exhibit different rates of skill loss and different asymptote levels of performance. Childs and Spears (1986), for example, found that some pilot skills decayed more rapidly than others. Wisher et al. (1991) distinguished three components of most tasks: knowledge, decision, and execution. These components, however, exhibit different decay rates when assessed independently. Research indicates that memory for job knowledge depends on how that knowledge is measured but generally shows fairly rapid forgetting (Wisher, Sabol, & Ellis, 1999). Research examining retention of decision skills suggests more moderate rates of decay (Wisher et al., 1999). In contrast, continuous skills, which encompass many highly practiced motor routines (e.g., typing), exhibit little or no loss over long retention intervals (Arthur, Bennett, Stanush, & McNelly, 1998; Childs & Spears, 1986). Depending on the task, military personnel may be required to acquire all three kinds of skills, which will then degrade at different rates.

To complicate the problem of predicting retention, numerous factors other than the type of skill also affect the nature of the skill loss function. We will discuss these factors in detail in Section 3.1 but factors such as the type of training, degree of initial learning, and individual differences affect the slope and asymptote of the function. Thus, to predict retention, one must consider a multidimensional representation of the skill.

Although decay of skill performance is ubiquitous, it may be possible for learned skills to endure for very long periods of time. A number of researchers have proposed a "permastore" memory that preserves skills and knowledge with essentially no amount of forgetting (e.g., Fendrich, Healy, Meiskey, Crutcher, Little, & Bourne, 1988). Some researchers have demonstrated very high retention over long intervals for such tasks as Spanish language training (Bahrick, 1984, cited in Fendrich et al., 1988), concept learning (Conway, Cohen, & Stannope, 1991), and some motor tasks. A common explanation for this high level of retention is that the skill has become automatized, consuming few cognitive resources and seemingly isolated from processes that lead to degradation of skills and knowledge (Anderson, 1995; Fendrich et al., 1988)

3.2 Military Tasks

Military tasks require a variety of skills. While one task may involve predominantly psycho-motor skills i.e. tracking, another may involve perceptual skills i.e. identification of military vehicles, while still others require cognitive skills i.e. performing a combat estimate (problem solving). Most military tasks involve a number of skill components.

The various military tasks performed in the Land force are detailed in the Battle Task Standard (BTS). The BTS have been laid out and numbered by combat function and operation of war or transitional phase. Battle tasks are detailed for:

a) individual (only used in IBTS);
b) section/crew/detachment;
c) platoon/troop;
d) subunit;
e) combat team;
f) battalion/regiment/battle group; and
g) brigade group.

3.2.1 Individual Battle Tasks

The IBTS is derived from common Land environment specifications and are common to all members of Land Force Command exclusive of occupation specific skills. They are taught as initial individual training through general military training, environment, occupation and specialty training. Once these Battle Tasks have been mastered there is a requirement to evaluate proficiency to ensure combat readiness. The Individual Battle Tasks include:

a) Fire the C7/C8
b) Throw Grenades
c) Fire the C9 Light Machine Gun
d) Fire the C6 General Purpose Machine Gun
e) Fire the SRAAW (L)
f) Fire the 84 mm Carl G SRAAW (H)
g) Achieve Army Fitness
h) Apply Military First Aid
i) Perform Individual Fieldcraft
j) Perform Nuclear Biological Chemical Defence
k) Apply Mine Awareness
l) Navigate Using a Map and Compass
m) Communicate Using Communications Equipment
n) Identify Armoured Fighting Vehicles and Aircraft

Please see Annex A for an example of an Individual Battle Task

3.2.2 Occupation Specific Battle Tasks

While all land Force personnel must be able to master the IBTS, they must also master their trade or occupation specific Battle Tasks. These specific battle tasks are detailed in the following standards:

a) Air defence artillery BTS
b) Armour BTS
c) Field artillery BTS
d) Combat service support BTS
e) Engineer BTS
f) Infantry BTS
g) Medical BTS
h) Signal BTS

Please see Annex B for an example of an Infantry Battle Task.

3.2.3 Collective Battle Tasks

Individuals do not operate alone, but perform their missions in close cooperation with other arms, fighting as part of brigade groups, battle groups, combat teams, and company groups. Consequently, Battle Group and Combat Team Battle Task Standards (BTS) are used to train and evaluate the personnel and units at the battalion and company level respectively. Combat Team Battle Tasks include those listed in Table 3.1.

COMMAND 1001, Battle Procedure 1002, Establish and Operate a CP
FIREPOWER 2001, Employ Indirect Fire Support
INFORMATION OPERATIONS 3001, Maintain Operations Security 3002, Screen
MANOEUVRE 4001, Attack 4002, Establish a Fire Base
PROTECTION 5001, Cross a Contaminated Area 5012, Emplace Obstacles
SUSTAINMENT 6003, Treat and Evacuate Casualties 6004, Handle PWs / Detainees

Table 3.1. Combat Team Battle Tasks.

Please see Annex C for an example of a Battle Group Task.

3.3 Military Training

3.3.1 Theories of Training

Fallesen and Pound (1998) identify three broad approaches to training. One is a *formal approach* that is highly structured and focuses on explicit rules and procedures. The training is derived from formal theories and models and conveys a great deal of declarative knowledge. Lecture-based courses are examples of this approach.

A second approach is based on *intuitive* theories of decision making and performance (Bryant & Webb, 1999). This approach emphasizes performance, cue differentiation, and the acquisition of automaticity. Training is done by practical exercises with feedback to allow individuals to acquire experience comparable to being on the job.

The third approach is a *hybrid* approach that combines explicit teaching of concepts and procedures but reinforces this with practical exercises. The first step is to identify expert strategies for solving problems in the domain and teaching novices how to apply these strategies.

Fallesen and Pound (1998) surveyed the literature and identified over 65 individual training strategies (see Pound & Fallesen, 1994, cited in Fallesen & Pound, 1998). They found that informal training strategies are often preferred over formal strategies for training in military settings. That is, military training emphasizes recognitional and procedural techniques rather than informational content. The goal of training appears to be to help trainees develop experience that can be applied in the field, especially the ability to recognize situations. Thus, current training techniques are generally consistent with intuitive theories of decision making.

Nevertheless, Fallesen and Pound (1998) advocate a hybrid training approach. Instruction includes components of declarative description of concepts and procedures. These are supported by exercises designed to reinforce those concepts and procedures. Trainees learn by applying skills in realistic scenarios. Thus, this approach involves more implicit learning than does classroom instruction but could be helpful early in training when novice trainees function in the cognitive stage (see Anderson, 1995).

Kozlowski et al. (1998) advocate a similar approach, involving practical exercises designed to give trainees experience with tasks. To facilitate comprehension and retention, exercises start at a simple level and become more complex as trainees master the material. Kozlowski et al.'s (1998) approach also emphasizes the use of feedback to promote learning. In particular, they advocate the use of feedback to provide evaluation, attribution, and guidance.

Evaluation lets the trainee know whether his or her performance was correct or not. This is essential information but not sufficient to help the trainee learn. Feedback that provides attribution tells the trainee why his or her performance was incorrect. Specific *attribution* provides a breakdown of the correct and incorrect steps taken in an exercise and allows trainees to modify their understanding of the task at a detailed level. Finally, *guidance* provides information on how to correct errors that trainees can incorporate in their understanding.

3.3.2 Training Outcomes

One goal of training is to develop expertise in a given skill or set of skills. Some research has attempted to characterize the nature of expertise. Experts, of course, are individuals who have performed in the domain longer than novices and experts exhibit higher levels of performance. The crucial issue concerns the cognitive structures that experts have acquired through practice that lead to the better performance. Thus, researchers examining performance in domains ranging from chess (de Groot, 1965) to solving physics problems (e.g., Glaser & Chi, 1988, cited in Anderson, 1995) have attempted to identify the specific ways in which experts differ from novices.

Some of the essential elements of expertise (see Federico, 1995) are listed in Table 3.2. Many of these elements are basically descriptive. Experts perform faster and that is a feature by which we recognize expertise. Other elements are difficult to interpret. Experts possess better short-term and long-term memory skills but one can ask whether this indicates that memory improves with practice or that superior memory skills allow individuals to become experts. Still other elements indicate a degree of refining or improvement in certain cognitive skills. Thus, experts exhibit better organization of knowledge so that they are able to mentally group related concepts and create integrated representations of problems.

Elements of Expertise
• Experts perceive great numbers of interpretable patterns in their subject matter, indicating excellent organization of knowledge
• Experts perform faster and with fewer errors than novices
• Expert possess superior short-term memory (STM) and long-term memory (LTM) for domain-relevant material
• Experts perceive and represent problems in domain at a deeper, more conceptual, level than novices
• Experts quantitatively analyze problems to represent them mentally and specify situations and constraints
• Experts possess substantial self-monitoring skills when detecting errors, checking solutions
• Experts spend proportionately more time than novices constructing problem representations
• Experts possess larger sets of schemata than novices
• Expert knowledge is organized to greater degree so it is more accessible, functional, efficient to use
• Experts' problem perception is schema-driven, whereas novices' problem perception is based on general search strategies
• Experts exhibit more context-dependent performance than novices; novices possess context-free features and facts and rules for behaving

Table 3.2 – Elements of Expertise (from Federico, 1995)

Perhaps the major element of expertise is the acquisition of knowledge. Simply by practice, the expert encounters many situations and attempts many solutions to problems. In the process, this information is recorded in memory and organized. This store of information is extremely valuable for decision making components of skills.

The organization of knowledge, of course, is another key factor. In particular, expertise is developed when a person relates domain knowledge in terms of conceptual rather than surface elements. Experts recognize more meaningful aspects of problems and assign greater weight to the conceptual structure of the situation than novices (Federico, 1995). That is, experts look for features related to functions, goals, intent, and so on, and use these features to identify the problem as well as retrieve appropriate solutions. Novices tend to look for the most salient, observable features that indicate some surface similarity to previous experience. The greater use of conceptual organization by experts allows them to identify solutions that address the meaningful issues of the problem.

It is important to note that experts and novices do not necessarily differ in the *amount* of conceptual or structural data they use when solving problems (Federico, 1995). Often, experts and novices sample the same data or information when performing tasks. Differences in their performance result from how experts and novices use data. Novices tend to perform in a *context-free* manner; i.e., they focus almost exclusively on elements of the problem at hand and ignore important situational cues. That is, they fail to connect the current situation to previous experience. Experts, on the other hand, perform in a *context-dependent* manner; i.e., they rely on cues that help them categorize the type of problem and relate it to previous experience. Experts may not process the data at hand to any greater degree than novices but they are able to link it quickly to their domain knowledge.

3.3.3 Training Implications of Expertise

The main implication of research on expertise is that training should provide large amounts of practice. Expertise involves acquiring large numbers of specific problem templates and solutions (Anderson, 1990). Because the expert ultimately stores this knowledge in a procedural form, it is essential that people directly experience domain problems by doing actual tasks. In this way, they can learn about all aspects of the domain while learning how to implement solutions.

Of particular importance in training is linking actions and solutions to schemata (Lipshitz & Shaul, 1997). During the second stage of expertise, a person forms associative memories that allow him or her to identify the appropriate actions given the situation. Explicit training can facilitate this process by identifying the critical cues and factors for categorizing situations and matching them to a template.

A second implication is that practice should be concrete and realistic but should also highlight the conceptual structure and principles of the domain. The conceptual structure consists of the critical cues and associations that link actions to templates and forms the basis of the way an expert identifies situations. Thus, training should help people look past the perceptual surface structure of the problem (i.e., the raw data) and identify meaningful aspects and relationships in the situation.

A third implication is that trainees need different forms of training at different stages of expertise. Initially, the trainee will function at the cognitive level. Training must, to some extent, focus on providing declarative knowledge of the domain in an analytic format that the trainee can understand and incorporate in his or her growing understanding of the domain. The training, however, must also help the trainee move to the next stage by providing practice in categorizing situations and associating responses. At the second stage, declarative information becomes less valuable and the focus of training should be on expanding the associative knowledge base of trainees. This can be done through extensive practice and explicit training in critical cues. Finally, as the trainee moves into the procedural stage, the trainee will require less formal instruction other than to find and remediate errors. What will be crucial is realistic simulation and practice to help the trainee apply what has been learned in real settings.

Anderson (1990) advocates a componential approach to training, in which material is broken into related sets of elements. These elements are taught individually through mastery learning techniques. With mastery learning, trainees study one component at a time, while their learning is monitored. Trainees do not advance until they have mastered the component.

4. Predicting Military Task Retention

Before reviewing models for predicting skill retention, we begin by examining factors that affect skill retention with the aim of setting the groundwork for a systematization framework. Such a framework is needed to evaluate models and understand the challenges of accurately predicting the decay of skill. We will then examine several modeling approaches, subjective, qualitative, and quantitative.

4.1 Factors Affecting Skill Retention

Researchers have spent considerable time identifying the relevant factors that affect skill retention (e.g., Arthur et al., 1998; Goldberg & O'Rourke, 1989). With these factors identified, researchers can characterize their relation to skill retention and estimate the magnitude of their effects. This is the first step in developing a useful model for predicting skill retention but not the only one. Functions describing the relationships between factors and retention must be scaled to indicate the course of skill loss over real units of time.

Much of the previous research has examined the qualitative effects of factors; that is, they have sought to determine the valence of the factor's effect (positive or negative) but not to generate a function relating levels of the factor to levels of skill retention. This is, for the most part, a practical decision because determining the quantitative relation requires greater expenditure of resources in terms of time, equipment, test subjects, and so on. Among the factors that have been examined are (see e.g., Arthur et al., 1998; Elliott & Wisher, 1993; Hagman & Rose, 1983):

- Length of retention interval.
- Degree of overlearning.
- Task characteristics.
- Methods of testing for original learning and retention.
- Conditions of retrieval.
- Use of mnemonics and other task aids.
- Instructional strategies or training methods.
- Prior experience.
- Individual differences.

These factors, and others, can be divided into four basic categories (see e.g., Driskell, Willis, & Cooper, 1992; Elliott & Wisher, 1993; Hagman & Rose, 1983; Schendel & Hagman, 1991):

- **Task factors**, which pertain to the nature of the task or skill to be acquired; e.g., complexity.
- **Training factors**, which pertain to the types of training manipulations employed in initial learning; e.g., length, style.
- **Learner factors**, which pertain to the individual differences and factors that affect learning and retention; e.g., aptitude, experience.

- **Retention interval factors**, which pertain to the events and manipulations occurring between training and performance; e.g., length, opportunity for practice.[2]

This is a pragmatic classification scheme and there is no theoretical reason to expect all factors within a category to be equally predictive of skill retention. Nor is there any theoretical reason to expect certain categories to be more predictive overall than another. It is an empirical issue as to the strength of relation of any specific factor to skill retention. Indeed, research suggests that some factors, such as duration of training and training workload, have little effect on long-term retention in and of themselves (Goldberg & O'Rourke, 1989).

As a result, we will not examine research pertaining to all factors that have been proposed to affect skill retention. Instead, we concentrate on those factors identified as the most relevant and used most often as a basis for prediction.

4.1.1 Retention Interval

Perhaps the most obvious factor to consider is the retention interval. Most people intuitively understand that the longer the period between training and performing a skill, the more likely a person is to show some degree of forgetting or decrement in performance. Indeed, research indicates that the course of skill loss is highly predictable; performance tends to decrease rapidly soon after training and continues to drop but at an increasingly slower rate as the retention level increases (see Section 2.1.5). The problem with considering retention interval as a factor is that time itself is presumably not a causal factor but a covariate of underlying processes (such as neurological processes) that produce skill loss (Arthur et al., 1998). Both memory trace decay and interference between learned skills have been advanced as theoretical accounts of the effect of retention interval, although neither provides a complete explanation (Adams, 1987).

If time is not a causal factor, the amount of skill loss must be influenced by other factors, including characteristics of the task, training, and individual. For example, researchers have suggested that the relation between skill loss and retention interval is mediated by the degree of initial learning, method of testing, conditions of retrieval, instructional strategies, among other factors (Arthur et al., 1998). Certainly, retention interval itself does not produce skill loss because some skills, such as highly practiced, continuous motor skills, show very little decrement even over long retention intervals (Arthur et al., 1998).

Nevertheless, retention interval is likely to covary with many factors that do have a causal relation with skill loss. This fact, in conjunction with the ease of measuring retention interval relative to measuring other factors, make retention interval a convenient variable to consider in predicting skill retention. The CF regularly utilizes retention interval for identifying when to impose refresher training. Historically, many of the battle tasks are practiced and tested annually (Annual Refresher Training). As well, there are a number of specialty trades training policies that recommend the frequency and progression of training (see Table 4.1).

[2] Researchers often identify aspects of the retention interval as training factors but it is useful to distinguish factors associated with the kind and quality of training from factors associated with events and activities occurring between training and performance of tasks.

TYPE OF TRAINING	LEVEL OF TRAINING			DESCRIPTION
	DETACHMENT	SECTION	PLATOON	
Indoor Tracking	W			W = weekly
Outdoor Tracking	M			M = monthly
Battle Run-Detachment	Q			Q = quarterly
Battle Run-Section		Q		S = semi-annually
Platoon Exercises			S	A = annually
Live Fire	A			
AFV Identification	W			
Gun Drills	M			
Fire Control		M	Q	
TGT Engagement Data		Q		

Table 4.1: Recommended refresher training practices for the TOW anti-armour system.

4.1.2 Opportunity to Practice

Another factor retention interval factor is the opportunity to practice afforded individuals between training and performance of the skill. One source of evidence supporting this factor comes from studies of the effects of Operations Other Than War (OOTW) on retention of combat skills. OOTWs consist of humanitarian, peace, and noncombatant evacuation operations that generally do not exercise combat skills and provide almost no opportunity to practice such skills (Blankmeyer, 1998).

In one study, Landry and Campbell (1997) hypothesized that OOTW would degrade combat readiness of US Army units and that the effects would be largely predictable, although the effects should vary by type of unit and OOTW. Fifty-seven active duty Army officers with OOTW experience responded to a questionnaire by rating the level of readiness of the respondent's unit before, during, and after the OOTW deployment. Respondents indicated that prior to deployment units were ready on almost all normal combat skills. Only 15% of respondents, however, reported having training opportunities for combat skills during the OOTW deployment and most respondents indicated that the impact of this was to degrade combat readiness. Respondents indicated that units were not combat ready upon return from deployment and required substantial retraining time.

Although most respondents in Landry and Campbell's (1997) survey indicated that OOTW deployment a negative effect on combat readiness, some claimed that OOTW improved the readiness of the unit. Most of these respondents, however, were from Combat Service Support (CSS) units, which engage in fewer combat tasks than other units. Respondents from CSS units reported that their OOTW tasks (e.g., driving trucks) complemented critical "go-to-war" tasks to some degree. Thus, these units seem to have received practice during the OOTW.

The decline in combat readiness of units deployed on OOTW suggests that lack of practice promotes skills loss but there are other factors that could confound this interpretation (e.g., interference). To examine the role of practice, Ford, Quinones, Sego, & Sorra (1992) defined opportunity to perform a skill in terms of three dimensions:

- **Breadth**: number of trained tasks that a trainee actually performs on the job.
- **Activity level**: amount of task repetition.
- **Type of tasks performed**: complexity and difficulty of tasks, which affect opportunity to perform.

Together, these dimensions define the amount of practice a trainee will receive for trained skills. Ford et al. (1992) identified several factors that affect opportunity to perform. The organization plays a large role as each department or functional unit creates its own goals and values that guide assignment of personnel to tasks. The work context created by supervisor and peer attitudes toward the trainee will also increase or decrease opportunities to practice skills. Finally, individual characteristics, such as level of ability, motivation, and self-efficacy, guide performance on the job.

To examine the impact of these factors, Ford et al. (1992) sent surveys to personnel trained in the US Air Force Aerospace Ground Equipment Airman Basic-in-Residence technical training course and their job supervisors. The surveys measured opportunity to perform trained tasks in terms of breadth, activity level, and types of tasks. Correlation analyses indicated that work context, individual factors, and organization were each significantly related to opportnuity to perform trained tasks on the job. Work context and individual factors were somewhat more strongly related to opportunity to perform than organizational structure, indicating that individuals in the same unit may have different levels of practice over time.

Other studies have observed a direct relation between the length of the non-utilization period and amount of skill loss (see Hurlock & Montague, 1982, for a review). This relation holds true when the interval is spent without practice. It is also clear, however, that other factors interact with non-utilization of skills to cause performance to decline at different rates. Although some studies have found no difference in the effectiveness of massed and spaced practice schedules (Elliott & Wisher, 1993), others indicate that the predictability of the practice schedule can affect trainees' performance. In one study, for example, Shute and Gawlick (1995) examined the effects of different practice schedules on learning and retention of problem solving strategies. Participants used either a consistent practice schedule or engaged in a varied number of practice trials for each problem type. Contrary to prediction, participants who received abbreviated practice opportunities exhibited better retention than those who received consistent practice. Shute and Gawlick (1995) argued that variable practice induces learners to invest more effort into learning and to develop more efficient problem solving strategies that are less subject to forgetting over time. Wisher, Kern, Sabol, & Farr (1994) report that aptitude, as assessed by the US Army's Armed Forces Qualification Test (AFQT), also mediates the negative effect of nonutilization on skill retention.

4.1.3 Degree of Learning

One of the most important determinants of the level of performance of a skill after some retention interval is the initial level of learning. A great deal of research has examined the effect of this factor, although often this research has confounded the effects of degree of learning with those of the amount of training (e.g., Lance, Parisi, Bennett, Teachout, Harville, & Welles, 1998). Hagman and Rose (1983), for example, reviewed studies conducted by the U.S. Army Research Institute (ARI) that examined the effect of amount of training/learning. In one study (Hagman, 1980b, cited in Hagman & Rose, 1983), trainees' performance on an electrical repair task was a direct function of the number of times they had performed the task during training, suggesting that those who learn more initially will retain more later. Retention is not solely a function of practice. In a review of the literature, Hurlock and Montague (1982) found that other factors that enhance initial learning, such as degree of aptitude, facilitate retention over time.

From this literature comes the concept of overtraining or *overlearning*, in which trainees receive additional training beyond that needed to achieve some criterion level of performance (Schendel & Hagman, 1980, cited in Hagman & Rose, 1983). For example, given that one group is trained by a number of trials (X trials) required to achieve a criterion of one correct performance of a task, overlearning would entail administering twice that number of training trials (2X trials). Retention of a range of skills has been demonstrated to be better given some degree of overlearning (Goldberg et al., 1981, cited in Hagman & Rose, 1983; Schendel & Hagman, 1980, cited in Hagman & Rose, 1983).

Overlearning can enhance retention by a number of mechanisms. It may strengthen the associations between stimulus and response, thereby decreasing the probability of forgetting (Arthur et al., 1998; Lance et al., 1998). If so, overlearning would also encourage automaticity or proceduralization, which reduces cognitive demands and promotes better long-term performance (Anderson, 1983). Overlearning by its nature entails more practice of a skill, providing greater feedback regarding correctness of responses (Arthur et al., 1998; Lance et al., 1998).

In a recent study, Lance et al. (1998) examined the effect of overlearning on retention of representative Air Force Specialties (AFSs). Airmen were categorized on the basis of their level of prior experience, the length of time since they last performed the relevant tasks, and the number of times they have performed the tasks on the job. Lance et al. (1998) measured task performance for all airmen and found that it was positively related to prior experience and the number of times tasks were performed. The results, however, were somewhat mixed as this relation was not found for all AFSs

Driskell, Willis, and Cooper (1992) suggest that there is some limit to the benefits of overlearning. They performed a meta-analysis of research to determine the precise effects of overlearning and found that a minimum of 50% overlearning (i.e., training plus the addition of trials equal to one half the original training) was required to observe any positive effect of overlearning. Thus, if too little overlearning is attempted, one is unlikely to observe a positive relation between overlearning and retention.

Refresher training is often used to counteract the effects of forgetting and maintain proficiency of skills (Schendel & Hagman, 1991). The key, as evidenced by the focus of this literature review, is to determine the rate at which skills decay and schedule refresher training such that proficiency does not decline below a criterion level. Extra training enhances retention regardless of whether it is provided during the initial training or in a refresher training session at some point during the retention interval (Schendel & Hagman, 1980, cited in Hagman & Rose, 1983). Other research on overlearning suggests that refresher training at any point in time can have a positive effect on long-term retention as long as a sufficient degree of overlearning is achieved (Driskell et al., 1991). Practical issues of cost and availability of personnel, however, require that refresher training be conducted in an efficient manner. Schendel and Hagman (1991) argue that refresher training sessions be conducted at intervals similar to usage intervals experienced on the job. That is, if personnel perform a task about once every month on the job, then refresher training need not be scheduled more frequently than that.

4.1.4 Method of Training

The amount of initial learning is obviously related to the amount of initial training. Thus, this factor has also been identified as a predictor of skill retention (e.g., Hurlock & Montague, 1982). The relationship between training and retention, however, is not so simple and many aspects of training affect skill retention. Again, Hagman & Rose (1983) have summarized early research and noted that studies have indicated that retention performance is affected by such factors as whether trainees are tested during training, whether practice trials are spaced or massed during training, and whether trainees practice on constant or varied equipment.

Hagman (1980a, 1980b, cited in Hagman & Rose, 1983) and Hurlock and Montague (1982) have found that trainees who were tested during training performed better at retention than those who received only presentation training. Test taking may simulate the actual performance environment, improving transfer from training to the job. Test taking can also stimulate practice and development of more effective performance strategies by trainees.

Schendel and Hagman (1980, cited in Hagman & Rose, 1983) and Hagman (1980c, cited in Hagman & Rose, 1983) found that spacing repetitions and practice sessions enhances long-term retention, provided the interval between repetitions is not too long (see Schendel & Hagman, 1991). One possible explanation is that varied practice schedules force trainees to expend greater cognitive effort because they must engage in more retrieval of learned material. Shute and Gawlick (1995) tested this possibility by contrasting the impact of an abbreviated practice condition to an extended practice condition on trainees in a flight engineering task. In the abbreviated condition, trainees received only one quarter the problems as the extended condition. Perhaps counter-intuitively, trainees who received abbreviated practice had better retention than those in the extended practice condition. Shute and Gawlick (1995) suggest that trainees in the abbreviated condition devoted greater effort during training to compensate for fewer practice trials. In one experiment, some trainees received mixed practice scheduling (abbreviated in the first half of training then extended for the second half, or vice versa). These trainees performed best of all on tests of retention, again indicating that variable practice schedules enhance retention. Spacing also allows learners to store skills in relation to a greater variety of retrieval cues (Schendel & Hagman, 1991), improving use of skills on-the-job.

The kinds of feedback provided during training also affect retention, depending on their informational content. Feedback can serve a motivating purpose, in which case its effects may not extend beyond the training session. When feedback contains information about the magnitude and direction of performance errors, however, it directs the learner towards ways of correcting the error and improving performance.

People generally need feedback, or "knowledge of results," to correct errors, observe and use cues associated with task performance, and generate effective procedures (Hurlock & Montague, 1982). This effect can extend to long-term retention. In one review, Schmidt (1997) examined the benefits of informational feedback and observed that feedback has two opposing effects on retention. Feedback aids learning, leading to better initial learning and longer retention, but also builds reliance on the feedback. In the latter case, the learner suffers performance decrement when the feedback is no longer present, which impairs retrieval of skills on the job. The goal of training should be to make use of the informational content of feedback but to avoid presenting feedback so frequently or in such a regular sequence that the learner incorporates feedback in their mental representation of the task.

Some training techniques provide means for learners to continue practicing skills after the training session has ended. Cognitive training consists of mental rehearsal strategies in which a learner mentally simulates the step-by-step performance of a task (Childs & Spears, 1986). This requires instruction in the task and guidance toward the mental cues needed to imagine performing the task. After training, however, the learner can use the technique whenever desired to provide practice. Empirical evidence supports the effectiveness of cognitive training in maintaining flight skills (see Childs & Spears, 1986), which is especially effective for practice of perceptual and cognitive aspects of tasks.

4.1.5 Similarity of Training and Performance Environments

Similarity of the retention environment to the original learning environment promotes retention (Arthur et al., 1998). This finding derives from the *Encoding Specificity Principle* of memory, which states that cues to retrieval will be effective if and only if encoded at the time of learning (Tulving, 1983). In the context of skill retention, this implies that perceptual and cognitive cues are needed to retrieve and perform learned skills. If the retention environment does not present these cues, performance will suffer.

Healy, Fendrich, Crutcher, Wittman, Gesi, Ericsson, and Bourne (1992) review a number of studies demonstrating cases of both remarkably good skill retention and very poor retention. On this basis, they advanced the *Procedural Reinstatement Proposal* that the retention of a learned skill depends on the extent to which learning procedures are reinstated at the time of retention. In this case, the cues to retrieval are the very procedures originally learned. The implication of this proposal is that to retain skills over long intervals, one must ensure that procedures used when learning the skill are reinstated later. For example, if training employed a job aid or checklist to aid learners in sequencing steps, that aid will be an important cue needed to reinstate the skill at a later time.

A study by Marmie and Healy (1995) illustrates this effect. They examined learning and retention of tank gunner skills, which were trained using the TopGun simulator used by the U.S. Army. Other theoretical perspectives predict poor retention of these skills due to the complexity and cognitive nature of the task (Adams, 1987, cited in Marmie & Healy, 1995; Driskell et al., 1992, cited in Marmie & Healy, 1995). The procedural reinstatement proposal, in contrast, predicts extremely good retention because the task is largely procedural and the procedures are reinstated during actual performance. In two experiments, trainees showed very little forgetting over retention intervals up to 22 months, verifying predictions of the procedural reinstatement proposal. These results also rule out a simple monotonic relationship between task complexity and retention.

4.1.6 Type of Task

Although Marmie and Healy (1995) suggest limits on the effects of task complexity, many researchers have considered task characteristics to be very important to skill retention. The classical distinctions include (Arthur et al., 1998):

- Physical vs. cognitive.
- Continuous vs. discrete.
- Natural vs. artificial.
- Speed (require performance in specified amount of time) vs. accuracy (require performance to a specified level of accuracy).

In their review of the literature, Arthur et al. (1998) found that skills associated with cognitive tasks, natural tasks, speed tasks, and open-loop tasks tend to be better retained than skills associated with physical, artificial, accuracy, and closed-loop tasks. Hurlock and Montague (1982) also report better retention of open-loop or continuous tasks. A great deal of research indicates that continuous skills show little or no forgetting over retention intervals of months or even years (Schendel & Hagman, 1991). Hurlock and Montague (1982) speculate that discrete, procedural tasks are more poorly retained because of the large number of discrete steps to remember and the even more difficult problem of remembering the precise sequence of steps. Consistent with this idea is the finding that tasks that have a meaningful organization or coherence of steps tend to be better retained (Hurlock & Montague, 1982).

Complex procedural skills are particularly susceptible to rapid decay (Schendel & Hagman, 1991). Forgetting of such skills, however, is moderated by the organization of the steps making up the procedure (Schendel & Hagman, 1991). One advantage of well-organized tasks may be that procedural steps act as natural cues for each other, making them easier to remember. Shields, Goldberg, and Dressel (1979, cited in Hagman & Rose, 1983) found that soldiers generally forgot steps of common soldier tasks that were not cued by equipment or previous steps (e.g., safety steps). Other studies have confirmed that uncued steps, steps judged to be difficult, steps addressing safety, and steps at the beginning and end of the task tend to be the most difficult to remember (Osborn et al., 1979, cited in Hagman & Rose, 1983).

4.1.7 Method of Testing

Different measures of performance can indicate different levels of retention (Arthur et al., 1998). Two common tests, for example, are recall and recognition. Recall requires the learner to generate learned material or skills, often in response to only a few cues. Recognition requires the learner to simply assess the familiarity of material and verify its accuracy. As a result, recognition performance tends to be better than recall performance across a wide range of tasks (Arthur et al., 1998). Research has shown, however, that recall and recognition are largely independent measures of memory (see Tulving, 1983). These two tests can assess different aspects of memory and, hence, reveal differences in retention of selected components of a skill.

4.1.8 Individual Differences

Although many individual characteristics could potentially affect skill retention, researchers have focused on a few fundamental ones, of which the most notable is general ability or aptitude. A common hypothesis has been that learners of lower ability forget skills more rapidly than higher ability learners (Lance et al., 1998). Indeed, a number of studies have found that, when training time is fixed, higher ability personnel learn more than lower ability personnel and that this translates into better retention (see Hurlock & Montague, 1982). Other studies, however, have yielded more mixed results as aptitude moderated retention for some but not other tasks (Lance et al., 1998).

Even when ability is found to affect skill retention, however, it is often unclear whether that factor is truly causal. Hurlock and Montague (1982) report that when high and low ability groups are trained to the same level of proficiency on a task (which will take different amounts of training), no differences in retention are observed. A great deal of research indicates that individuals of different ability levels do not differ in their *rates* of skill loss (see Schendel & Hagman, 1991).

Another issue concerns the precise nature of ability, which can be defined in a number of ways. One view is that ability corresponds to general cognitive ability (referred to as *g*) (Spearman, 1927). Ree, Carretta, and Teachout (1995) reviewed a number of studies that documented the effectiveness of *g* as a predictor of job performance and suggested that g could predict on-the-job performance of US Air Force pilots after their 53-week training course. They collected pilots' scores on the verbal and quantitative subtests of the Air Force Officer Qualifying Test (AFOQT) to serve as measures of *g*. Job performance was assessed by flying work samples and academic grades. Composing a measurement model, Ree et al. (1995) determined that *g* had only an indirect effect on job performance; *g* positively affected prior job knowledge and job knowledge acquired through training, which in turn affected job performance.

Another approach to defining ability is to assess multiple specific abilities to determine how each affects performance. In one study, Earles and Ree (1992) examined the validity of the ten aptitude tests of the Armed Services Vocational Aptitude Battery (ASVAB) as predictors of training performance. They found variability in the effectiveness of the various subtests, with Arithmetic Reasoning and Mathematics Knowledge being the best individual predictors. Composite scales created by combining sets of subtests could be even more effective predictors of performance. Similar multi-scale aptitude tests have been developed for other domains, such as air traffic control, and have sometimes been found to have limited predictiveness of training performance (Ackerman & Kanfer, 1996).

Motivation is another commonly investigated individual factor that seems to have an effect on training performance, although its effect on retention has been less well established (Hurlock & Montague, 1982). Motivation may increase learning during training, which leads to better performance over time. Lack of motivation after training, however, does not seem to increase the rate of skill loss. Related personality factors, including self-efficacy and mastery beliefs may, however, affect the expression of learned skills over time (Zazanis & Lappin, 1998). Self-efficacy is the internal sense of competence pertaining to a given skill. Low self-efficacy has been found to impair performance. Consequently, factors that reduce a person's sense of competence over the span of a retention interval may depress performance further.

4.2 Transfer and Retention of Skills

Before considering models of skill retention, we must clarify the relation between skill retention and skill transfer. Typically, researchers consider skill retention to refer to situations in which skills are applied in work settings anticipated during training. In contrast, skill transfer is taken to refer to situations where skills are applied to tasks and situations not explicitly anticipated during training. Any trained skill, however, will be applied in situations that differ in some ways from the training environment, so that it is never the case that training and performance tasks are exactly the same (Schmidt & Bjork, 1992). Thus, skill retention and skill transfer appear to differ in degree rather than quality. Training objectives should always be to maximize performance when skills are transferred from training to the job environment (Kraiger et al., 1993).

This view of retention is consistent with the procedural reinstatement proposal (Healy et al., 1992). Because effective performance of a skill depends on reinstating the procedures used to acquire the skill, we can see that it is possible to envision cases in which "retention" as it is typically defined might be worse than "transfer" as it is typically defined.

4.3 Subjective Approaches

Perhaps the most straightforward means to predict retention and estimate the need for refresher training is to ask the learner how much of the learned skills have been retained. Such a technique, of course, may not be very accurate. This section reviews subjective approaches that seek valid and reliable means to use learners' self-knowledge to estimate skill retention.

4.3.1 Meta-Cognition and Self-Assessment

Perhaps due to an inherent mistrust of self-assessments of learning, relatively few studies have examined learners' abilities to estimate their own level of skill retention in applied settings. However, meta-cognition, the cognitive processes used to monitor one's own thoughts and memory processes, has been studied quite extensively in laboratory settings. Early on, it became apparent that people were fairly good at predicting the ease of learning of verbal materials; that is, they could accurately predict which items were likely to be well remembered (e.g., Underwood, 1966, cited in Zechmeister & Nyberg, 1982). Research also investigated related judgements of knowing, which consist of rating the likelihood of remembering studied items. This judgment differs from estimating ease of learning by estimating what *is* known rather than what *will be* known. The two are not exactly the same as an item rated as difficult to learn might, after extensive study, be rated as well known. Research indicated that, overall, people make accurate judgments of knowing but that their ratings do not reflect the effects of some basic and powerful factors, such as serial position and meaningfulness (e.g., Arbuckle & Cuddy, 1969, cited in Zechmeister & Nyberg, 1982).

Self assessments have been used to examine skill acquisition and job performance in domains such as the health professions (e.g., Schwiebert & Davis, 1995). In a review of the literature, Gordon (1991) compared performance in health care training as self-assessed with performance as assessed by experts or objective tests. He found that generally self-assessments of performance were closely related to generalized self-attributions (e.g., self-efficacy) and minimally influenced by external feedback (tests, grades, faculty assessments). Although self-assessment appeared to be only marginally accurate, Gordon did note findings that suggested that instruction in making self-assessments could improve the validity of this technique for predicting performance levels.

One study of military skill retention examined the usefulness of self-assessments as predictors of skill retention. Wisher et al. (1991) examined skill retention of soldiers in the Individual Ready Reserve (IRR) who were mobilized for Operation Desert Storm. These soldiers had completed active service but received no training or practice in combat skills while in the IRR. Wisher et al. (1991) distributed questionnaires to soldiers after their re-certification training. The questionnaires assessed how often soldiers perform relevant skills in civilian life, how many MOS skills were remembered at the time of call-up, how technically prepared the soldier was after training, and overall confidence in capability to perform. Wisher et al. (1991) then gathered actual performance data of soldiers during their mobilization and compared this to their assessments of knowing from the questionnaires. They found that soldiers' self-assessments were good predictors of retention of MOS skills but that they were somewhat biased, being too optimistic.

Other research suggests that self-assessments are relatively poor predictors of skill retention. Schendel et al. (1984, cited in Schendel & Hagman, 1991) found that soldiers' predictions of their own retention of a task accounted for only about 10% of the variance associated with task performance scores. Most of these soldiers overestimated their retention. Schendel and Hagman (1991) consider self-assessment a potentially useful technique considering its convenience and specificity but perceive it as not currently refined enough to be used in the field.

4.3.2 Refresher Training Estimates

Even if military personnel are able to assess the state of their knowledge and skill retention, they may not be able to use that information to accurately determine their need for refresher training. Schendel and Hagman (1982) hypothesized that people's good metacognitive abilities should allow them to directly estimate their need for refresher training and to adjust their own refresher training schedule. In their study, they examined learning of the general assembly/disassembly of the M60 machinegun. Soldiers in the control condition were trained to criterion on this task, tested for retention after an eight week retention period, then retrained to criterion. Soldiers in an overtraining group were trained to criterion plus an additional 100% overtraining, then similarly tested and retrained. A refresher training group received the same amount of additional training as the overlearning group but received it midway through the retention interval. All groups were asked, prior to the retention test estimate how much of the skill they retained and how many retraining trials they would need to return to their criterion level of proficiency. The overtraining and refresher training groups exhibited better retention, as expected, but all groups were very accurate in making their refresher training needs estimates. Gross overestimates of need occurred only infrequently and 73% of soldiers' estimates were within one trial of being correct. Thus, Schendel and Hagman (1982) concluded that it is possible to accurately predict refresher training need by soldiers' subjective self-assessments.

4.3.3 Applicability and Practicality of Subjective Approaches

The evidence in support of subjective approaches tends to be inconclusive. Certainly, empirical findings amply demonstrate that people have some ability to assess their own levels of retention and need for refresher training (Schendel & Hagman, 1982; Wisher et al., 1991) but it is unclear exactly how accurate are these self-assessments. Indeed, to be useful in a military setting, a model must be calibrated to the kinds of tasks, training and performance environments, and retention intervals in real job settings. Further research is needed to determine how self-assessments are affected by these factors before a practical approach can be developed. In particular, attention should be devoted to examining military tasks, as only a few studies have addressed this domain.

Regardless of the true accuracy of self-assessment, a major obstacle to employing a subjective model will be the perception among commanders and trainers that self-assessments cannot be trusted. Certainly, subjective approaches are vulnerable to malingering in the form of deliberately inaccurate self-assessments, although various techniques can be used to guard against this (Iverson, Franzen, & McCracken, 1991). Commanders and trainers may be reluctant to base training decisions on a model that does not entail objective assessment of factors determining retention. This mistrust may be partially mitigated by education about subjective approaches but is unlikely to be completely eliminated.

A subjective approach requires little in the way of materiel because self-assessments can be collected by paper-and-pencil or computerized questionnaire. The main resource requirement is manpower to administer and monitor the process of collecting self-assessments. This requirement, however, can be reduced by training commanders and staffs in the field to administer and score questionnaires themselves. Self-assessments, of course, must be gathered for each individual soldier, meaning that a large amount of data must be analysed to determine the retention level at the unit level.

4.4 Qualitative Approaches

The ultimate goal for prediction of skill retention is to generate accurate, quantitative estimates of the rate at which skills degrade over time. This level of precision, however, can be very difficult to achieve. Consequently, some researchers have developed models that offer only quantitative predictions of skill retention. That is, the models indicate categorically how skills fade over time in relation to certain key factors. These models, as they stand to date, do not solve the practical problems of predicting when proficiency of skills will decline below a criterion or when refresher training will be needed but they do offer approaches that may be developed into quantitative models in the future.

4.4.1 Training Criteria

One of the classes of factors that will affect skill retention is the nature of the training; certain forms of training will lead to longer retention than others. Kirkpatrick (1959a, 1959b, 1960a, 1960b, cited in Alliger, Tannenbaum, Bennett, Traver, & Shotland, 1997; see also Arthur et al., 1998) developed a classification scheme to evaluate training effectiveness with an eye toward predicting learning and retention. The scheme contains four categories (or *steps* in Kirkpatrick's taxonomy) of measures of effectiveness of training outcomes:

- Step 1: **Reactions** (liking, attitudes toward the training).
- Step 2: **Learning** (knowledge obtained).

* Step 3: **Behavior** (using learned principles).
* Step 4: **Results** (desired benefits to the training organization).

Kirkpatrick's classification scheme allows trainers to measure, albeit roughly, the characteristics of the training course to determine the extent to which learners will benefit from the training. In its present form, the scheme does not allow quantitative evaluations but trainers can rank different training courses by these characteristics to predict which training courses will yield greater benefits, including better initial learning and longer retention.

Alliger and Janak (1989) note several problems with Kirkpatrick's classification scheme, although these often arise from misunderstandings of how the scheme should be applied. First, trainers often assume that the steps in the scheme are arranged in ascending order of importance, which they are not. This may lead to the view that the best measures of success of training are based on Step 4, such as reducing training costs, increasing morale, and so on. The relative importance of steps will depend on the goals of training. In the case of military training, Steps 2 and 3 would be primary because the need is to ensure military personnel are able to perform tasks when called upon.

A second problem is that the steps in the scheme do not have clear causal links. Reactions, for example, do not predict learning; trainees may learn well when training is unpleasant and involves hard work. There should be some causal links between steps – learning and behavior should be positively correlated – but we do not know the exact form of these links.

In an attempt to correct problems with Kirkpatrick's scheme, Alliger et al. (1997) offered an augmented classification scheme based on a meta-analysis of relationships between training criteria. This scheme, shown in Table 4.2 below, expands the reactions and learning categories. At the reactions level, Alliger et al. (1997) divided trainees views of training into affective and behavioral (or utility) components. Thus, Step 1a concerns affective reactions such as satisfaction, which partially determines motivation to learn and perform. Step 1b concerns the perceived utility of the training for subsequent job performance, which affects the degree to which the training will influence the trainee view the training as enhancing ability to perform.

Kirkpatrick's taxonomy	Augmented Training Criteria
1. Reactions	Reactions a. Affective reactions b. Utility judgments
2. Learning	Learning a. Immediate knowledge b. Knowledge retention c. Behavior/skill demonstration
3. Behavior	Behavior
4. Results	Results

Table 4.2. Augmented Training Criteria of Alliger et al. (1997) Compared to Kirkpatrick's Classification Scheme.

At the learning level, Alliger et al. (1997) divide the category to reflect the distinction between declarative and procedural knowledge (e.g., Tulving, 1983) as well as the initial level of learning. Step 2a is an evaluation of immediate post-training knowledge, usually assessed by multiple choice tests or factual knowledge. Level 2b refers to the long-term retention of declarative knowledge needed to perform the trained skill or task. Level 2c deals with the behavioral or skill retained from training, which is assessed by the actual performance of trained skills and on-the-job performance. The remaining two Steps are unchanged from Kirkpatrick's original scheme.

To assess the validity of their revised classification scheme, Alliger et al. (1997) conducted a meta-analysis of 34 articles examining training criteria. The meta-analysis confirmed earlier findings (Alliger & Janak, 1989) that inter-correlations among levels are modest but inter-correlations among criteria within the same level are stronger. Overall, both affective and utility reaction criteria and immediate and retained measures of learning correlated moderately with on-the-job performance, suggesting some predictiveness of skill retention. All training criteria were reliable evaluations. The small number of studies examining the effectiveness of training criteria, however, limit their usefulness as a model for prediction of skill retention (Alliger et al., 1997).

4.4.2 Relapse Prevention Model

Marx (1986) offers another approach that is based on individual characteristics and training outcomes as a means of combating skill loss. The Relapse Prevention Model, however, is more a strategy for preventing skill loss than a model for predicting the rate of skill loss. Nevertheless, it can be used as a diagnostic tool for identifying whether a learner has the necessary *support skills* that slow the decay of learned skills. It can also be used as a training intervention to increase the long-term retention of skills.

Support skills are techniques and procedures, sometimes explicitly taught, that are used to monitor and enhance one's own learning and performance. Marx (1986) argues that any critical management tasks, such as leadership and decision making, depend on several support skills, such as creating an effective support network and recognizing behaviors that lead to errors or lapses. If an individual is deficient in support skills, he or she is less likely to retain new skills or knowledge beyond the end of training. Thus, Marx advocates training in support skills to help trainees understand their value. With increased awareness of where new skills are vulnerable to failure, managers can self-diagnose support skill deficits.

The Relapse Prevention Model helps trainees be more sensitive to difficult aspects of future training situations and to identify potential causes of training failure by using information of past failures as feedback. An implicit assumption underlying the model is that skill failure or forgetting is not due to decay alone but, at least partially, to contextual forgetting or the mismatch between training and performance environments (e.g., Godden & Baddeley, 1975; Tulving, 1983). For example, a training course might teach a manager delegating skills but, when back in the actual work environment, the characteristics of the training situation are largely unavailable. As a result, the manager does not have access to many of the cues needed to initiate and monitor the trained skill and so performs worse than at the end of training. Moreover, a working environment often presents frustrating obstacles to employing new skills, inducing the person to revert to old skills. Consequently, Marx (1986) argues that managers need to be taught to anticipate the on-the-job environment and recognize the need for support skills to enhance the transfer from training to work environment. The Relapse Prevention Model identifies self-control strategies to aid this process.

Relapse prevention strategies			
Strategy (S) Anticipate and monitor potential difficulties	**Purpose**	**Example**	**Proposed Remedy**
Understand relapse process.	Helps anticipate the RP process.	No time to concentrate on skill retention.	Return to work expecting difficulty in skill retention.
Observe differences between training and work setting.	Decreases unpredictability of hectic work environment on retention.	Little feedback from my supervisors and co-workers.	Set time for participative decision making with my work group and supervisor.
Create an effective support network.	Helps identify co-workers who will support skill retention.	After training, it's business as usual.	Meet with and observe other trained workers.
Expect subordinates' skepticism of new behaviors.	Reduces perceived insincerity when implementing new skill.	Co-workers might appreciate, but won't trust, my sudden change.	Announce participative decision making, ask for input, and start only occasional use.
Identify high-risk situations.	Helps pinpoint situations where relapse is likely.	- When work piles up – When I've been working too hard and feel tense.	Schedule first group decision meeting during a lull in the week.
Avoid implementing new skills in overwhelming situations.	Allows choice of appropriate, safe setting.	Usually use new skills at the first opportunity even if conditions are unfavorable.	Schedule meeting two weeks after training, when the backing of work has diminished.
Recognize seemingly unimportant behaviors that lead to errors.	Strengthens awareness of behaviors that leave managers overwhelmed.	Inadvertently scheduling participative decision last.	Make sure the group decision is item "one" on the agenda.
(O) Increase rational thinking Reduce dysfunctional emotions.	Diminishes irrational guilt or self-blame for early lapses.	Self-blame for not mastering group decision making quickly.	Expect to feel some self-blame but allow feeling to pass.
Retain self-confidence despite temporary errors.	Reframes temporary lapses as expected.	Angered by subordinates, drop the whole idea, thus lowering my confidence.	Perceive the lapse as a unique event caused by inadequate skill development not personal inadequacy.
(B) Diagnose and practice related support skills Diagnose necessary support skills.	Enables assessment of support skills.	Poor time-management skills sabotage effective participatory decision making.	Improve time management skills via a course.
Review disruptive lifestyle patterns.	Identifies persistent personal habits that can disrupt skill retention.	A perfectionist, worried about not doing things right, doesn't try.	Consider personal counseling. Perfectionism may seem less with exercise. Keep up health and fitness programs.
Mix required and desirable activities.	Helps manager balance enjoyable and tedious activities.	Unpleasant tasks occur early in the week. Slips are likely when fun tasks aren't available.	Meet with the enjoyable groups early in the week.
(C) Provide appropriate consequences for behavior Assess organization support for skill retention.	Anticipates where self-managed rewards must supplement missing organizational support.	Boss won't notice or focus on skill improvement.	Instruct boss about the skill. Invite her to a meeting, and ask for feedback on progress at performance review.
Create meaningful rewards and punishments when they otherwise don't exist.	Teaches how to identify, create, and implement appropriate consequences.	Self-punishment for skill lapses.	Reward yourself for even model attempts. Set specific rewards, long- and short-term.

Figure 4.3 – Relapse Prevention Strategies (From Marx, 1986).

Another key assumption of the model is that skills will be more effectively retained if the degree of unpredictability of the working environment is reduced. This can be accomplished in several ways. Managers can be taught to expect slips or failures and to use these as data for predicting and dealing with future difficulties. They can be taught to view failures as feedback on the effectiveness and completeness of training. Finally, Marx (1986) developed a set of relapse prevention strategies (Table 4.3) that serve as "cognitive fire drills." These help prevent errors or failures in skill performance from becoming permanent loss of skill capability.

The relapse prevention strategies are divided into four categories:

- **Stimulus situation**: Pertain to work environment.
- **Thoughts and feelings (Organism)**: Pertain to the self.
- **Behavior**: Pertain to one's own behavior.
- **Consequences of behavior**: Pertain to interaction with the organization.

These categories can be made the focus of training to enhance support skills. The first step in implementing relapse prevention strategies is to choose or identify the skills to be retained. The learner then describes the skill in measurable terms so that errors and slips can be detected. After identifying the skills, the trainee is presented with relapse prevention strategies (see Table 4.3) to apply during training and afterwards in the work environment. The final activity is for trainees to predict the circumstances of errors and lapses in performing skills. The trainee creates a detailed image or mental simulation of the scenario so that when it begins to happen in the work setting, the trainee can recognize it and apply relapse prevention strategies.

Marx (1986) argues that large organizations can use the Relapse Prevention Model as part of a training needs assessment process. By identifying the most common support skill deficits, training objectives can be chosen to optimally meet training needs. The model also aids in developing training schedules, choosing training style, and assessing skill loss on-the-job.

4.4.3 Model of Job Performance Determinants

McCloy, Campbell, and Cudeck (1994) developed the Model of Job Performance Determinants as a descriptive model of the factors that directly determine individual differences in job performance. Although this model was not intended to predict skill loss rate, it might be adaptable to this purpose. The model is based on the assumption that task performance is multidimensional and that for any task there are a number of performance components that differ in their intercorrelation with other variables.

The main determinants of performance in this model are all individual factors:

- **Declarative Knowledge (DK)**: Facts, rules, principles, and procedures.
- **Procedural Knowledge and Skill (PKS)**: Automatized procedures, routines, motor programs.
- **Motivation (M)**: Combined effect of three choice behaviors; choice to expend effort, choice of level of effort to expend, and choice to persist in expenditure of effort.

Job Performance Components (PCs), then, are a function of DK, PKS, and M. All other factors are hypothesized in this model to indirectly affect PCs by their effects on DK, PKS, and/or M. Good supervisors, for example, can enhance DK and M, leading to better performance. The effects of situational and training factors, then, can be predicted by knowing their effects on the three underlying factors.

There is little empirical support for McCloy et al.'s (1994) claim. In one test, they analysed various test types to predict which factors would be determinants of performance. Performance on job knowledge tests, they hypothesized, would be a function of DK, that is job knowledge. Performance on work sample tests, which measure capability to perform tasks, would be a function of both DK and PKS. Supervisor ratings of performance would be a function of all three factors, DK, PKS, and M. McCloy et al. (1994) collected performance data from first-tour soldiers in 19 MOSs, including:

- Hands-on performance tests.
- Job knowledge tests.
- Records of awards and letters.
- Task ratings by supervisors and peers.
- Cognitive ability tests.
- Spatial ability tests.
- Perceptual speed and psychomotor tests.

In support of their predictions, McCloy et al. (1994) found that cognitive ability tasks were most predictive of DK and moderately predictive of PKS; there was little relation with M. Psychomotor tests were most predictive of PKS and moderately predictive of DK but showed no relation with M. Personality variables were strongly predictive of M but showed little relation with DK and PKS.

4.4.4 Applicability and Practicality

The training criteria approach was designed to apply to any kind of training and, hence, any kind of skill. Because this model addresses the nature of training, it is not important to characterize the task in any great detail. The approach is also easy and inexpensive to use. It can, in principle, be applied once for a given training course to generate predictions of skill retention any future time the course is administered. In practice, however, training criteria would have to be evaluated each time a training course is conducted because a course will vary from trainer to trainer.

The main disadvantage of the training criteria approach is that it has not been developed into a quantitative model. It offers broad indications of how quickly skills will fade based on the kind of training given but cannot indicate the rate of skill loss or the asymptote level of performance in units of real time. This approach also has received relatively weak empirical support, suggesting that the scheme as currently formulated is too simple to provide accurate predictions of skill retention (Alliger & Janak, 1989).

The Relapse Prevention Model suffers from similar problems. Again, the model makes no quantitative prediction of skill retention and it is unclear how this capability could be developed within the framework laid out by Marx (1986). The model is aimed at providing strategies to maintain skills rather than prediction and would probably be more useful as a technique to improve the effectiveness of refresher training. Moreover, the model was developed for managerial skills, which tend to be highly cognitive. Thus, the model may not apply to primarily procedural and motor skills common in the military. The Relapse Prevention Model, however, would entail only moderate effort and cost to implement, primarily in the form of additional training requirements for trainers, commanders, and other military personnel.

The Model of Job Performance Determinants applies to all kinds of skills, given its focus on the learning and intrinsic motivation of trainees. It is unclear what effort and resources would be required to apply model in assessing DK, PKS, and M. Given that these are based on individual factors, however, it would presumably require fair amounts of manpower and resources to assess DK, PKS, and M for each soldier and each skill.

This approach has not been fully developed and researchers have yet to describe the functions relating DK, PKS, and M to performance. Thus, this model provides no quantitative predictions of skill retention, although it might with further development. There needs to be systematic analysis of correlations between factors and DK, PKS, and M. Empirical evidence so far has been limited; additional support is needed to validate this approach.

4.5 The ARI Model of Skill Retention

The most fully developed model of skill retention is the User's Decision Aid (UDA), developed by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) (Rose, Radtke, Shettel, & Hagman, 1985a; Rose, Czarnolewski, Gragg, Austin, Ford, Doyle, & Hagman, 1985b). This model was developed specifically to provide quantitative predictions of skill retention for military tasks and so represents a major advance from the qualitative models reviewed so far.

4.5.1 Theoretical Bases

Much of the empirical literature discussed in Section 3.1 served as a basis for the UDA model. As researchers uncovered the personal, task, training, and job condition factors that affect skill retention, they began to work on descriptive procedures to identify more precisely how these factors produced deterioration of skills (e.g., Hurlock & Montague, 1982). The ARI established their modeling effort to develop and validate a convenient, practical method for unit commanders and training managers to decide upon the allocation of training resources to maximize combat readiness (Rose et al., 1985b).

The first issue dealt with in the ARI initiative was the decision as to which factors were relevant to prediction of skill loss as well as feasible for use in prediction. The ARI rejected the approach of testing large numbers of soldiers on each Army task to empirically derive individual retention curves because this would require far too many resources (Rose et al., 1985b). Instead, they sought to identify relevant factors already established at that time in the research literature, using these to develop theoretic retention curves for use in prediction of skill loss.

Several ARI projects investigated the effects of training variables, including overlearning (Hagman & Rose, 1983), practice schedules (Schendel & Hagman, 1982), and innovative training techniques (Rose et al., 1985b), all of which affect the rate of skill loss[3]. In addition, ARI studies identified a number of task characteristics that have dramatic effects, such as task difficulty, number of steps required, inter-step cueing, and step relevance (Rose et al., 1985b). In contrast, studies revealed only inconsistent effects of individual ability measures such as the AFQT and Armed Services Vocational Aptitude Battery (ASVAB) (Rose et al., 1985b), although other studies suggest predictable effects of personal factors (Ackerman & Kanfer, 1986; Ford et al., 1992).

Deciding that training and individual factors presented certain practical problems of assessment, ARI focused on task factors as predictors (these are summarized in Table 4.4)[4]. Wisher et al. (1999) review the major factors identified. One of the major predictors of skill loss is task complexity, which can be divided into three sub-factors: number of steps in a task, whether the steps must be performed in a set sequence, and whether there is built-in feedback that indicates correct performance of steps. As the number of steps increases, retention performance of tasks decreases (Knerr et al., 1984, cited in Wisher et al., 1999). This effect is modified, however, by the organization of steps in the task.

[3] Several ARI studies did, however, fail to replicate the finding that retention is related to the degree of initial learning (Rose et al., 1985b)

[4] There is inherently greater variability in the way training is administered for a task from one unit to another than in the way the task is actually performed.

Memory for order is often poor, which makes tasks within which steps can be performed in any order easier to retain than tasks within which steps must follow a particular order.[5] Nevertheless, tasks in which steps must be performed in one specific order are generally not that difficult to retain compared to tasks in which some steps must be performed in order but others can be performed in any sequence. Single-sequence tasks simplify the problem of remembering order and present clearer cues to the correct sequence of steps. Tasks that naturally present feedback concerning the accuracy of steps can further aid retention of a skill by reducing errors and preventing an individual from proceeding down the wrong track before realizing an error.

Another set of task factors pertain to the demands the task places on performers (Wisher et al., 1999). One such factor is the amount of information or number of facts that the performer must recall in order to perform the task. Consistent with the "magic number 7±2" (Miller, 1956), people can easily remember 5 to 9 *chunks* of information but encounter difficulty with more than 9 chunks, unless they employ some strategy to subjectively re-code the information into fewer than 9 chunks (e.g., Simon, 1974).[6] The availability of such strategies will itself depend on the nature of the information; abstract information may be difficult to re-organize.

Tasks can also place execution demands on performers. As noted earlier, continuous tasks tend to be retained better than discrete tasks (Arthur et al., 1998; Hurlock & Montague, 1982), presumably because they require an intermediate degree of motor control and involve less sequencing of steps. Memory for cognitive skills also tends to be stable for long periods of time, although they do exhibit forgetting (Wisher et al., 1999). People tend to show greater skill loss for cognitive skills than for perceptual-motor skills.

To combat the limitations of human cognition, the designers of tasks often create job and memory aids to help performers remember steps as well as necessary information. These vary in quality and comprehensiveness but the availability of an effective job aid helps individuals retain relatively high levels of performance over time.

Time limits inherent to a task can impair retention of skills. An aspect of skill loss is the slowing of performance as performers take more time to remember and execute steps. As a result, a time limit can impair performance by preventing the performer from finishing or by creating stress that hinders the performer's expression of skill.

Task Factors Identified by the ARI
1. Number of steps
2. Whether steps must be performed in a set sequence
3. Whether the task contains feedback that indicates the correct order of steps
4. Number of facts or information chunks that must be recalled
5. Execution demands

[5] This effect is likely confounded with the effect of overall number of steps because tasks in which steps can be performed in any order presumably tend to have fewer steps than sequential tasks.

[6] A chunk is typically defined as an elementary unit of meaningful information, so that a chunk depends on how an individual organizes information.

6.	Whether the skill is cognitive or perceptual/motor
7.	Whether there are job and/or memory aids for the task
8.	The time limit of the task (if any)

Table 4.4. – Task Factors Identified During the Development of the UDA Model of Skill Retention

4.5.2 Development of the Model

The major responsibility of the ARI project was to determine a way to keep soldiers proficient in tasks (Rose et al., 1985a). Given that soldiers will forget, the ARI concentrated on developing a tool to increase the efficiency of scheduling refresher training. Training time should be spent on tasks in which soldiers have dropped, or are about to drop, below a criterion level of performance. To schedule training when needed (but not before), the ARI developed the UDA model on the basis of the task factors identified. The model predicts the decay rate of tasks over periods during which soldiers have engaged in no practice. There is no means by which to account for the effect of practice on skill retention.[7]

The UDA was developed according to a few basic steps (Rose et al., 1985b):

1. Identify task dimensions most likely to be related to retention.
2. Convert task dimensions into rating scales, develop anchor points, and analytically assign weights to each point on the scales.
3. Assess each scale's reliability and validity by having several judges rate tasks on each scale.
4. Examine inter-rater agreement and correlation between task ratings and actual retention data.
5. Iterate these steps to develop a set of valid and reliable scales.

Rose et al. (1985b) describe each of these steps in detail, effectively laying out a "cookbook" for development of a model of skill retention. The remainder of this section will briefly describe the methodology.

The basis of the UDA model is the algorithm that weights and summarizes the relevant task factors to produce a single task retention score. This score is then used to predict soldiers' level of task proficiency over time. ARI researchers developed the initial algorithm from the empirical literature available. To refine the algorithm, researchers then performed regression analyses on data obtained from previous ARI studies. The regression equations obtained for the set of eight task variables (Table 3.3) indicated substantial correlations between retention at two months and each factor. Correlations between retention at four months and the factors were not as high but still significant. Thus, the initial algorithm suggested a viable means to predict skill retention.

To refine the algorithm further, ARI researchers collected performance data from soldiers for a sample of 13B10 (cannon crewman) MOS tasks. These data was used to empirically establish acquisition and retention functions (performance plotted as a function of time) and to examine the relationships of task factors to retention. The MOS tasks used in this phase of the project were all basic skills pertaining to restricted duty positions. A total of 11 tasks could be tested within the time and equipment constraints of the study.

[7] The UDA model assumes that initial training has brought soldiers to a criterion level of one perfect performance (100% proficiency) of the task/skill (Wisher et al., 1999).

Based on these early studies, researchers were able to develop and implement the UDA procedure to empirically determine the values for each rating option of the UDA questions. The researchers also improved the comprehensibility of the rating procedure based on user feedback. It is worth noting that the ARI researchers created the preliminary model using arbitrary assumptions rather than deriving scale values empirically. Furthermore, the relative weights for rating scales and the rule for combining them were also arbitrary. The researchers did this because they had not had access to a sufficient pool of tasks to conduct regression analyses necessary to determine best-fit values, necessitating the initial arbitrary estimates.

To increase the number of cases, researchers combined data sets from multiple studies to create a data set containing data on a total of 54 tasks. To decrease the number of task characteristic predictors, they performed a factor analysis of the task dimensions comprising the UDA, which reduced the number of independent predictors to five. Eight raters then made ratings for the 54 tasks. From the data set, the researchers determined the percent soldiers GO (i.e., the percentage of soldiers in the study who were at or above the criterion performance level) and the percent task steps GO (the percentage of task steps for which soldiers were at or above criterion performance)[8]. Analyses resulted in empirically-based scale values for the answer options within each UDA rating question. This scaling procedure is critical to convert the retention level predicted in the model into a value for "real-world" retention. It also provided regression weights for each UDA question to account for differences in the importance of different factors.

We can break down this procedure into five more specific steps. The first step involved creating a matrix of the raters' modal responses arrayed by UDA questions and the 54 tasks. In step 2, the researchers input the mode matrix into an analysis of variance (ANOVA) and conducted separate ANOVAs for each of the eight UDA questions, with percent soldiers GO as the dependent variable and answer options for each question as the independent variables. They then generated cell means for each answer option of five of the questions; the remaining three questions had non-significant F values and so weights were assigned arbitrarily. The researchers then transformed the mode matrix by replacing each entry with the corresponding cell mean from the ANOVA. Thus, the matrix values corresponded to the mean percentage of soldiers GO for all tasks with a given question option. For example, this would change a rating of "2" in the question pertaining to the presence of job aids to "61.3," which was the mean percent of soldiers GO for all tasks with "Good" job aids. The factor analysis indicated that four questions loaded significantly onto one factor, which could be interpreted as the cognitive demands of the task. Thus, researchers combined these questions into a single independent variable by adding values.

The third step was to multiply matrix values by the question weights. The regression analysis examined the relationship between five UDA variables and mean two-month retention performance across the 54 tasks. The results indicated that 79% of the variance in performance was accounted for by the five predictor variables.

Step 4 involved transforming the scale values. The weights were rounded off to the nearest whole number and a constant added or subtracted for each UDA question so that the lowest value equaled zero. The sum of the additions and subtractions were added to the regression equation constant so that the transformations had no effect on the regressions but improved the usability of the scales. The final step was to add up the eight transformed scores for each task to arrive at a total UDA score for each task.

[8] The term GO indicates that personnel are capable of performing a task successfully.

The purpose of the UDA model is to generate numerical predictions of skill retention. Thus, an important issue is how to relate predictions of the model to actual performance; in other words, what does a UDA value of, say, 86 mean and how can it be used to estimate performance (Rose et al., 1985b)? The translation of UDA value for predicting two-month retention performance is straightforward because the option weights and combination rule were developed from data on two-month retention performance; a UDA value of 86 is a prediction of 86% of 40 (the constant in the regression equation) or 26% proficiency after two months. ARI researchers followed an iterative process to develop a generative function to allow prediction at any retention interval. They hypothesized a generation function, generated it for two- and four-month retention intervals, compared the predicted and actual retention levels, then revised their hypothesis and repeated the procedure. Various functions were compared in terms of the obtained correlation and absolute arithmetic error between actual and predicted retention scores. The best fitting function was:

$$\text{Predicted Proficiency for Week Y} = 100 \times ((\text{UDA}/100)^{1/8})^{y}$$

Thus, retention performance after Y weeks of no practice is predicted by dividing the UDA value (after subtracting the constant) by 100, taking the eighth root, raising the result to the Yth power, then multiplying by 100. For two months, Y = 8, and the formula reduces to just the UDA score. When used to generate predictions for the four-month as well as two-month retention intervals, the ARI team found a correlation of 0.83 between actual and predicted retention performance. The absolute error of prediction was less than one half of one percent.

Having achieved a high degree of accuracy in prediction, researchers turned to improving the usability of the UDA. Actual and potential users of the model were interviewed. Based on this feedback, researchers revised the questions and instructions to improve comprehensibility and convenience of the UDA as a tool for predicting skill retention.

4.5.3 The UDA Decision Aid

The UDA model was developed to form the basis of a decision aid tool to be used in predicting skill retention and the need for refresher training in military tasks (Rose et al., 1985a). Specifically, the UDA is used to determine (Rose et al., 1985a; Wisher et al., 1999):

- How quickly task skills will be forgotten.
- Which task among several will be forgotten or remembered after a specified interval.
- What percentage of soldiers will be able to perform a task after up to one year without practice.
- When to conduct refresher training to keep a group at a criterion level.

The UDA employs ratings of task characteristics to predict skill retention. The ratings are made by individuals with extensive knowledge of the task. Optimally, more than one person performs task ratings to ensure accuracy (Rose et al., 1985a). Differences in ratings must be resolved by discussion because the UDA accepts only certain values and averages of ratings have no meaning in the model. All that is required to make task ratings is a task summary that provides descriptive information that can help resolves differences of judgment and reduce the subjectivity of ratings (Rose et al., 1985a). If no task summary is available, having raters write their own summary can help them be more thorough and objective.

Question	Scale Values	Factor
1. Are job or memory aids used by the soldier in performing (and in the performance evaluation of)	1 (yes), 0 (no)	Task Characteristic; Presence of job aid

this tasks?		
2. How would you rate the quality of the job or memory aid?	56 (excellent), 25 (very good), 2 (marginally good), 1 (poor)	Task Characteristic; Presence of job aid
3. Into how many steps has the task been divided?	25 (one), 14 (two to five), 12 (six to ten), 0 (more than ten)	Task Characteristic; Number of steps
4. Are the steps in the task required to be performed in a definite sequence?	10 (None), 5 (all), 0 (some are and some are not)	Task Characteristic; Organization
5. Does the task provide built-in feedback so that you can tell if you are doing each step correctly?	22 (for all steps), 19 (for greater than 50% of steps), 11 (for up to 50% of steps), 0 (for none)	Task Characteristic; availability of feedback
6. Does the task or part of the task have a time limit for its completion?	40 (no time limit), 35 (easy time limit), 0 (difficult time limit)	Task Characteristic; Stress
7. How difficult are the mental processing requirements of this task?	37 (almost no requirements), 28 (simple requirements), 3 (complex requirements), 0 (very complex requirements)	Task Characteristic; Difficulty
8. How many facts, terms, names, rules, or ideas must a soldier memorize in order to do the task?	20 (none), 18 (one to three), 13 (four to eight), 0 (more than eight)	Task Characteristic; Difficulty
9. How hard are the facts, terms, that must be remembered?	34 (not applicable; none to remember), 31 (not hard at all), 12 (somewhat hard), 0 (very hard)	Task Characteristic; Difficulty
10. What are the motor control demands of the task?	2 (none), 0 (small), 16 (considerable), 3 (very large)	Task Characteristic; Difficulty

Table 4.5. – UDA Questions and Scale Values

The UDA contains ten questions that raters answer based on the task summary and their knowledge of the task. Each question has a set of answers to choose from. Raters select the appropriate answer and note the scale value associated with the selected answer. The questions and their scale values are listed in Table 4.5. When all ten questions have been answered, the raters compute the total of the scale values, which constitutes the task's retention score. Multiple raters review the ratings given to the task and resolve differences to produce a final, agreed-upon task retention score.

The UDA contains two Performance Prediction Tables that are used to convert the total retention score into a prediction of performance for the rated task. The numbers in the tables represent the expected *proportion* of soldiers in a unit that are able to perform the task correctly at various retention intervals up to one year without practice. The UDA does not predict retention performance for individuals. The first table plots the expected proportion of soldiers versus monthly intervals, whereas the second table plots the expected proportion of soldiers versus weekly intervals (see Table 4.6).

Predicted Proportion of Soldiers at Criterion Performance Level

	Months Since Last Performance							
Total Score	1	2	3	4	5	6	7	8
180+	100	100	100	100	100	100	100	100
175	97	95	92	90	87	85	83	81
170	94	90	85	81	76	72	69	65
165	92	85	78	72	66	61	56	52
160	89	80	71	64	57	51	45	40
155	86	75	64	56	48	42	36	31
150	83	70	58	49	40	34	28	24
145	80	65	52	42	34	27	22	17
140	77	60	46	36	27	21	16	12
135	74	55	40	30	22	16	12	9
130	70	50	35	25	17	12	8	6
125	67	45	30	20	13	9	6	4
120	63	40	25	16	10	6	4	
115	59	35	20	12	7	4		
110	54	29	16	8	4			
105	50	25	12	6				
100	44	20	8					
95	38	15						
90	31							
85								

Table 4.6 - UDA Performance Prediction Table (Month Intervals) (Adapted from Rose et al, 1985a)

To find the percentage of soldiers expected to be able to perform the rated task, raters find the table entry corresponding to the total retention score and the retention interval of interest. To determine how frequently refresher training is needed, raters find the row corresponding to the total retention score then locate the table entry of 50% (or any other criterion). The retention interval at which the criterion occurs is the maximum interval for refresher training to sustain a unit at the criterion level. The tables can also be used to determine what level of proficiency is expected for a unit that receives refresher training at a given interval of time (e.g., every X months). The expected proficiency is given by the table entry corresponding to the total retention score and the interval (X months).

4.5.4 Empirical Evaluation

The ultimate goal of any model of skill retention is to accurately predict performance as a function of time. This is tested by comparing predictions of retention performance made by a model to observed retention performance of individuals under representative conditions. The UDA model has been extensively examined and evaluated by ARI researchers. However, many studies cited in support of the UDA (such as Macpherson, Patterson, & Mirabella., 1989; Sabol, Chapell, & Meiers, 1990; Wisher et al., 1991; Wisher, Sabol, & Ozkaptan, 1996; see Wisher, Sabol, & Ellis, 1999) did not actually compare predicted retention performance to actual retention performance. As such, they do not provide a true validation of the UDA because it cannot be determined how accurate is the UDA in predicting skill retention.

In fact, only one study reports a comparison between UDA predictions and actual retention data. Rose et al. (1985b) used data collected from a sample of 22 13B10 (cannon crewman) MOS tasks that had not been used in the development of the UDA to compare predictions of the UDA to actual skill loss. They calculated Pearson product-moment correlations between actual and predicted scores for percent soldiers GO and percent steps GO. For all tasks, these correlations were significant, although predicted means were about four points lower than actual scores at the two-month retention interval. The tendency to underestimate scores increased with the length of the retention interval. Rose et al. (1985a) suggest that numerous factors, such as experimental manipulations of feedback and baseline proficiency, events during the retention interval, and individual differences may account for the underestimation of proficiency.

4.5.5 Applicability and Practicality

The UDA is one of the few approaches for which empirical research has been done to assess its applicability and practicality. In one study, Macpherson, Patterson, and Mirabella (1989) used the UDA to predict skill retention for a set of nine 63W10 MOS (vehicle maintenance) tasks (see Table 4.7). One of the goals was to determine whether the model could be used easily at the Aberdeen Proving Grounds.[9] Eight instructors from the Ordinance School's Wheeled Vehicle Department rated each task using the UDA and task lists prepared from Army technical manuals. The task lists included task steps, indicated which steps had to be performed in order, end-products of subtasks, safety requirements, and tools and materials needed.

[9] U.S. Army facility, Maryland.

Tasks
Diagnose hard starting
Diagnose loss of engine power
Diagnose stalling engine
Diagnose engine which cranks but does not start
Replace fuel injector pump
Remove and replace steering gear on an M35A2
Remove and replace axle on an M813A1
Remove and replace clutch on an M35A2
Remove and replace transmission on an M35A2

Table 4.7. – Vehicle Maintenance Tasks Examined by Macpherson et al. (1989).

The eight instructors took a total of 26 hrs, or 2.8 hrs per task, to complete their ratings and determine predicted retention. The total clock time involved was 10 hrs, or 1.0 hr per task. Each rater, working independently with an interviewer, took one hour to rate five tasks, or 12 minutes per task, per rater. A group discussion, led by an interviewer, took one hour for each of two groups of raters.

Macpherson et al. (1989) were able to generate retention curves for the nine tasks. These curves served as theoretical estimates of pure forgetting of unit task skills without intervening practice. From these results, Macpherson et al. (1989) were able to predict that tasks receiving total scores above 180 would not be forgotten within one year, the maximum interval spanned by the UDA. Skills for low to moderate scoring tasks should decay very rapidly compared to skills for tasks with higher scores. Based on the results, Macpherson et al. (1989) predicted the rank order of scales that differentiated among tasks in decreasing effect on retention:

- Technical manual quality.
- Mental requirements.
- Feedback provided by task.
- Number of facts to memorize.
- Ease of recalling memorized facts.
- Physical skill required.

This study demonstrated that it was feasible to use the UDA to differentiate and prioritize critical tasks. The raters were able to identify those tasks most susceptible to skill decay and make predictions of when refresher training would be needed. The study also demonstrated the practicality of the UDA. The use of the UDA is a cost-effective supplement to field studies that requires few materials and relatively little effort. The raters had no difficulty reaching agreement on scale values for each question of the UDA for each task. Thus, the resolution procedure of the UDA seems to work well and allows multiple raters to achieve a single retention score.

In a larger scale study, Sabol, Chapell, and Meiers (1990) used the UDA model to make predictions of the decay functions for 85 skills needed to operate Mobile Subscriber Equipment (MSE) (a communication system). MSE is a radio telephone system and its operation entails many complex, highly cognitive skills within MOS 31D (MSE Network Transmission Operator) and MOS 31F (MSE

Network Switch Operator). The purpose of their study was to predict retention of MSE operator skills and to expand the UDA to cover more complex skills than those examined in its development.

Sabol et al. (1990) had six SMEs from Delta Company, 442nd SIG BG serve as raters. Three of the SMEs were expert on MOS 31D procedures and three on MOS 31F procedures. Using exhaustive task inventories generated during the development of the MSE's Soldier's Manuals and lists of skills generated during field evaluation of MSE, the raters completed the ten question rating procedure of the UDA for all 85 tasks. Each SME was interviewed separately and took about two hours for MOS 31D tasks and about three hours for MOS 31F tasks. Sabol et al. (1990) reported that they intended to obtain data with which to compare predictions of the percentage of soldiers GO for each task to actual performance data of MSE operators. However, we were unable to identify any publication reporting the results of such a comparison.

Predictions of retention have been similarly computed for "peace support operations" tasks (Wisher et al., 1996). As in the Sabol et al. (1990) study, SMEs rated a number of tasks and these ratings served as a basis for computing skill retention curves using the UDA. Although no comparison to actual retention performance was made, the UDA predictions were sufficiently precise to allow researchers to rank order tasks in terms of their expected difficulty and susceptibility to forgetting. This rank order was distributed in a guide job aid to Army trainers for Operation Joint Endeavor in Bosnia.

The UDA has been demonstrated to be relatively easy to administer. Some training is needed to perform the ratings correctly and reliably but this training requirement does not seem to be excessively burdensome (Radtke & Shettel, 1985). The UDA itself is low-cost and requires no special equipment.

The applicability of the UDA for predicting retention of procedural tasks seems well established. It is less clear how well this model applies to predominantly cognitive or continuous motor tasks. The questions that make up the UDA may be adapted to these kinds of tasks but they seem less central. Moreover, the UDA was developed in the context of a variety of specialized skills drawn from U.S. MOS categories. Additional validation with basic and command skills is needed to assess the model's applicability.

Another potential problem with the UDA model is that it may neglect important factors. By relying exclusively on task factors, the UDA achieves a high degree of ease-of-use but may sacrifice accuracy of prediction. Factors such as the degree of overlearning (Hagman & Rose, 1983; Lance et al., 1998; Schendel & Hagman, 1980, cited in Hagman & Rose, 1983), opportunity to practice (Blankmeyer, 1998; Ford et al., 1992; Landry & Campbell, 1997), similarity of training and performance environments (Healy et al., 1992; Marmie & Healy, 1995), and possibly individual aptitude (Earles & Ree, 1992; Hurlock & Montague, 1982) have strong effects on skill retention. These factors, however, are more difficult to assess than task factors because they vary from person to person or training session to training session. Nevertheless, in light of the questions concerning the true validity and applicability of the UDA, it seems worth considering the role of training, individual, and retention interval factors in predicting skill retention.

4.6 Other Quantitative Approaches

The UDA is the most comprehensive and developed approach to making quantitative predictions of skill retention. Nevertheless, researchers have suggested other approaches, which will be discussed in this section.

4.6.1 Correlational Approaches

A fundamental tenet of research examining the effects of various factors on skill retention has been that accurate predictions of skill loss can be made when the relationship between those factors and skill retention is made clear. That was the approach taken by the developers of the UDA, who regressed a number of factors on skilled performance to determine their relation to retention (Rose et al., 1985a). Other researchers have performed similar, but much simpler, regression analyses to correlate the effects of one or two factors with retention.

One approach is to derive the empirical relationship between retention performance and the retention interval. Researchers examine retention of a skill at a few specific intervals then determine the best fitting function that describes the relation of retention to time (e.g., Grant & Logan, 1993; Wixted & Ebbensen, 1991). This relationship is expressed as a power function that can be used to generate predictions at any retention interval. The predictiveness of empirically derived functions depends on several factors:

- The representativeness of the tested sample to the population of prediction.
- The representativeness of the tested skills to the skills for which predictions are made.
- The reliability of the retention data used to generate the power function.

To afford prediction, a sample should be drawn from the population for which prediction will be made. What constitutes an appropriate sample depends on the tasks under consideration. Basic psychomotor processes differ very little across people from diverse backgrounds. Consequently, accurate prediction can often be made from samples of college students to virtually any population. Tasks involving more cognitive skills, however, are affected a great deal by the particular educational, social, and work environments of the people performing the tasks. As a result, samples that differ even slightly from the population under consideration can lead to functions that are poorly predictive.

Another approach is to determine the relationship of specific task, learner, training, and retention interval factors to retention. Given the large number of factors that have been found to have measurable effects on skill retention, however, it is difficult to envision a single correlational relationship being a very informative predictor. That is why researchers have focused on a few factors that seem to be especially critical and very convenient to assess. One of these is the degree of initial learning. First of all, this factor encompasses a number of training and individual factors that determine how much trainees learn. Secondly, most training techniques involve an end-of-course assessment of some sort, so that obtaining a measure of degree of learning is convenient and may not create additional costs or burdens for trainers.

In one study, Goldberg and O'Rourke (1989) examined the effects of amount of initial training, training workload, and length of retention interval on performance in a manual tracking task (skiing). Participants trained to error-free performance then returned after a one to six week period of no-practice for retraining and assessment. The training workload and retention interval were varied between participants and amount of training within-participants. The measures of retention were run completion times and number of retraining runs to re-achieve criterion. The results showed that performance at retention was more dependent on individual performance differences at completion of initial training than on the length of the retention interval, training workload, or amount of training. Goldberg and O'Rourke (1989) did not determine a function to predict retention performance based on training performance but suggest that this would be a viable approach.

Arthur et al. (1998) also advocated a correlational approach and attempted to determine quantitative estimates of the effect sizes of a number of potential predictors of skill retention, including:

- Length of retention interval.
- Degree of overlearning.
- Task characteristics:
  - Closed- versus open-loop.
  - Physical versus cognitive.
  - Natural versus artificial.
  - Speed versus accuracy demands.
- Methods of testing.
- Conditions of retrieval.
- Evaluation criteria

Factors Rank Ordered by Effect Size	
1.	Conditions of retrieval
2.	Speed versus accuracy task
3.	Physical versus cognitive task
4.	Closed- versus open-loop task
5.	Evaluation criteria
6.	Retention interval
7.	Method of testing
8.	Degree of overlearning
9.	Natural versus artificial task

Table 4.8. – Arthur et al.'s (1998) Ranking of Factors Affecting Skill Retention

They performed a meta-analysis of empirical findings to generate aggregate effect sizes across 52 relevant articles containing 189 independent data points. This provided an indication of the overall magnitude of skill loss over retention intervals. Each of the factors had significant effects on retention performance, as reviewed earlier in Section 4.2. To use these factors as predictors, Arthur et al. (1998) calculated effect sizes using the *d* statistic. This is a measure of the strength of treatment of the independent variable and is the standardized difference between two means. It represents the observed difference between experimental and control group performance in standardized deviation units (Cohen, 1990, cited in Arthur et al., 1998). The rank order of factors by effect size is presented in Table 4.8. This ranking differs from others that have been published (Farr, 1987, cited in Arthur et al., 1998) but the authors argue that their ranking is the only one based on a quantitative assessment of effect size.

The next step in Arthur et al.'s (1998) analysis was to convert estimates of effect size (*d* statistic) into predictions of retention in units of time. For example, the amount of skill loss associated with the retention interval ranged from a *d* of –0.1 immediately after training to a *d* of –1.4 after more than 365 days. Based on this value, Arthur et al. (1998) calculated that, after 365 days, an average individual would perform at roughly 8% of his or her initial performance level after training. Similar calculations can be made for any factor based on the d statistics determined for them.

Arthur et al. (1998) had intended to generate skill retention curves based on each factor to take into account the effect of retention interval for each factor. They were, however, unable to compute the necessary parametric statistics because the assumption of normality in the data was severely violated.

Thus, this technique was not able to provide a usable set of predictions based on the full range of relevant factors.

A problem closely related to prediction of skill retention is the prediction of skill transfer from one job to another. Here, the goal is to estimate performance at a task based on performance of a related task. Skill transfer is relevant because retention can be considered a special case of transfer in which a skill is transferred from the training environment to a similar but distinct work environment.

Kavanagh, Lance, O'Brien, Stennett, McMillen, and Solomonson (1997) discuss development of an Ease-of-Movement Matrix (EOMM), a tool for estimating transferability of skills among approximately 160 enlisted Air Force Specialties (AFSs). Their approach could be adapted to prediction of skill retention by including in the matrix the transfer from training to job performance. Transfer of skill is estimated in terms of the amount of retraining needed when an airman transfers from one AFS to a new one. The estimated retraining times within the EOMM would be organized by rows indicating 180 "From" AFSs and columns indicating 180 "To" AFSs.

Kavanagh et al. (1997) developed a Transfer of Skills Questionnaire (TSQ) for retrainees, supervisors/peers, and nontrainees. The TSQ assessed the number of months a trainee served in his or her present assignment, measures of actual time-to-proficiency of the trainee, measures of current job performance, and a measurement of transfer of skills developed by Lance et al. (1993, cited in Kavanagh et al., 1997). The questionnaire was given to a sample of 3000 retrainees, their supervisors and peers, and a set of nontrainees. The results indicated a significant convergent validity for each measure representing the underlying retraining-related variables. Correlations between cross-job retraining times indicated that these times are valid predictors of actual ease of retraining but not retraining success following reassignment. Retrainee aptitude seemed to play a larger role in determining job performance than what was learned during retraining. Thus, questions remain about the validity of the EOMM as a predictor of true skill transfer.

Perhaps the most radical of the correlational approaches is one that involves ignoring the causal factors of skill loss altogether. Sulzen (1997) conducted a study to determine the effects of home station training on performance at the US National Training Center (NTC). The results indicated that units expending more resources during home station training performed better at the NTC. Performance at the NTC was essentially a retention test, albeit one at a relatively short retention interval. The results suggested, however, that an actuarial approach might offer accurate prediction of unit performance levels over time. In this case, one would seek to estimate performance based on unit data, including resources used for training. Training expenditure is an indirect indication of initial learning but is easily and unambiguously measurable.

4.6.2 Applicability and Practicality

Empirically derived functions can offer highly accurate prediction of skill retention for any kind of skill. The major drawback of this approach is that it requires extensive effort and commitment of resources to select a representative sample, administer training, and test retention performance over a suitable range of retention intervals. Moreover, this process must be performed for every class of skill for which prediction will be made. Power functions will not generalize widely across different classes of skills and it is necessary to carefully examine the applicability of a function from one skill to another. Given the large number of skills trained by the CF, it would be a major undertaking to develop empirical retention functions for all skills.

Quantitative approaches that relate predictive factors to retention performance also tend to apply to the full range of military tasks, although which factors most predictive presumably varies from task to task. It may be necessary to develop separate models for different kinds of tasks, depending on the interaction of predictive factors with the type of task. In particular, continuous motor, procedural, and cognitive tasks may be optimally predicted by different sets of factors, or by different weightings of a single set of factors. Ultimately, the applicability of a quantitative model depends on the factors used to model skill retention.

The cost and workload associated with quantitative approaches are probably low because many factors are easy to assess. Some factors, however, might require that frequent measurements be made for all individuals taking refresher training. One way to deal with this potential problem is to randomly sample performance from a unit. This is a basic technique of empirical research and, assuming proper procedures are followed, yields accurate and reliable estimates of levels of performance of entire unit. Sampling reduces the costs of assessing individual factors because only a small fraction of soldiers are directly assessed. This technique can dramatically reduce costs without sacrificing much accuracy as long as a sufficient sample can be drawn from the population. There are two potential sources of error: a) error of measurement, b) error of sampling. Reducing errors of measurement is a matter of refining measurement techniques. Errors of sampling can be minimized by employing rigorous sampling procedures to eliminate bias in the sample and employing the technique for populations in which retention is normally distributed or by adjusting sampling techniques for a known distribution type.

5. Improving Skill Retention and Reacquisition

The rationale for *predicting* skill loss is to enhance our capacity to *reduce* it. With increasingly accurate estimates of the degree to which skilled performance will degrade over time, we can take various actions - better initial training, more frequent refresher training, provision of job aids, and so on - that will preemptively reduce or eliminate the decline in performance. This section briefly discusses some trends that will contribute to this effort. Moreover, changes in training and the work environment may dramatically alter the course of skill loss. It may be necessary to periodically review and revise methods for predicting skill loss to take into account the changing nature of training and other factors.

5.1 Effects of Training Technologies

The technology available to trainers and training developers will undergo dramatic changes in the next decade (Richard, 1997; Taylor, 1997). These changes hold the potential to greatly enhance the success of training and the long-term retention of skills. New technologies can enhance training and practice of military skills in three basic ways:

- Making better use of training methods and feedback.
- Expanding practical methods of training.
- Permitting more frequent practice.

Simulations and exercises have been a staple of military training, especially for combat and high-skill jobs. Improvements in computer technology allow trainers to make exercises more realistic and informative than in the past. Semi-Autonomous Forces (SAF), for example, are computer-based simulations used in tactical combat training (Kornell, 1999). These allow personnel to train in real-time settings against credible forces. SAFs, unlike live exercises, require little time or equipment and reduce the need for training facilities. Thus, personnel with access to personal computers can engage in training more frequently. Moreover, simulations allow for training opportunities that are impossible to create under field training (Brown, 1992, cited in Sterling & Quinkert, 1998).

Computers also expand the amount and specificity of feedback that can be given to trainees. Brown, Nordyke, Gerlock, Begley, and Meliza (1998) note two complementary forms of feedback typically used in military training: a) intrinsic feedback provided within exercises from the actual and simulated entities and activities, and b) extrinsic feedback provided by controllers/trainers in the form of criticism, reviews, coaching, and correction. Both forms of feedback are enhanced when computers can take over the workload for providing feedback. The more realistic and complete the exercise, the better is intrinsic feedback because the exercise more accurately models the cues and consequences associated with performance of skills in the work environment. Computer recording can enhance a trainer's ability to observe and analyse trainees' performance to provide more, and more accurate, extrinsic feedback.

Training devices, including computer simulations and multimedia training packages, reduce costs without reducing training effectiveness (Kornell, 1999). Indeed, they can improve training effectiveness while permitting trainees to engage in more instruction and exercises. As computers become easier to deploy, these benefits can be extended to units in the field for use in extended training or refresher training. Taylor (1997) notes that training devices can be viewed in two ways, as cheap training sessions and as devices used by units to slow the rate of skill loss, so that training sessions need be scheduled less often. In other words, training devices can enhance training so that military personnel achieve higher levels of initial proficiency and enhance practice opportunities so that skills are lost more slowly. There are many examples of training devices already in use by the US Army, including among others the Conduct-of-Fire Trainer (COFT) for armor, Precision Gunnery Training System (PGTS) and Basic Skills Trainer (BST) for infantry, and the Precision Range Integrated Maneuver Exercise (PRIME) for combined arms (see Taylor, 1997).

Deploying computer-based simulations and training packages to the field will allow units to address training deficiencies and skill loss for themselves (Sterling & Quinkert, 1998). The Graphical Instruction in LISP (GIL) is one example of a training device that can be used for self-teaching (Reiser, 1997). GIL emulates a human tutor by not only presenting lessons and exercises but monitoring and analysing trainees' performance to detect errors and bad strategies. Thus, GIL provides individualized feedback and correction and can even adjust lessons to the level of proficiency of each trainee. With access to such a training device, military personnel can seek refresher training frequently. As more training devices become available, units will be able to take advantage of the features of computer systems, such as their capacity to present vast numbers of different situations/problems, automatic scoring and feedback, and approximation of real-world conditions (Taylor, 1997). Flexible scheduling encourages military personnel to seek more practice opportunities.

5.2 Military Work Environment

Although changes in training technology will probably contribute to enhanced learning and retention, changes in the military work environment - roles, missions, equipment, etc. - may contribute to more rapid skill loss. Some analysts anticipate that the changing global political and economic situation is forcing the military to take on non-traditional roles and methods of operating (O'Neill, 1996). One especially important change has been the increasing deployment of combat forces to Military Operations Other Than War (MOOTW). Such deployments are of concern because combat forces must maintain proficiency to wage war under conditions that limit sustainment of warfighting skills (Taylor, 1997). Most MOOTW involve sensitive political issues and highly-constrained operations so that units rarely have access to training facilities. As a result, developing new training methods and deployable training equipment will become extremely important to sustaining skills.

Another problem will be the increasing complexity of the operational environment. More and more, the military employs complex technology. This requires military personnel and leaders to learn more new skills and to perform and think in a faster-paced environment (Richard, 1997). The "21st century soldier" will employ a great deal of technology but will have to think about what the equipment is doing and how to use it (Salter & Black, 1998). The most significant advances in military systems are combinations of improved hardware, software, and supporting equipment collectively known as *digitization* (Ford, Campbell, & Cobb, 1998; Salter & Black, 1998). The challenge will be to make use of the significant benefits of digitization in a way that assists the soldier rather than hindering through increased workload and interference with learning and performance.

The increasing digitization within the military increases the need for well-trained military personnel and, hence, for training programs (Salter & Black, 1998). Digitization also places a premium on cognitive skills, many of which are complex and difficult to learn. Computers and complicated equipment are often unforgiving of errors so that training must be intense to achieve adequate learning. Many cognitive skills are then prone to rapid forgetting, which increases the need for refresher training (Elliot et al., 1996, cited in Salter & Black, 1998). As a result, military personnel will likely be required to train more frequently and more intensely in the future. Salter and Black (1998) note that in Operation Desert Hammer VI, soldiers who had not received adequate hands-on experience with digital equipment simply were not proficient in using it. They concluded that training with actual equipment was needed for soldiers to learn and retain cognitive skills.

Ford et al. (1998) argue that digital development outpaces development of training programs. Moreover, many units of the US Army were judged to be unprepared for the added training load of digitization. Ford et al. (1998) note the need to develop training requirements and to allocate resources to meet those requirements.

Training in new cognitive skills, however, may hurt retention of other, more traditional skills. Learning new skills always has the potential to interfere with memory for previously learned skills (Adams, 1987). If digital skills are given intense training, this interference effect will naturally be more severe. Furthermore, there is only limited time during which military personnel can train. Scheduling training for new skills will take away time and resources that could be spent training or refreshing basic combat skills.

5.3 Strategies for Sustaining Readiness

As researchers have examined ways to predict skill retention, their ultimate goal has been to improve the sustainment of performance or readiness. From the research have come three broad strategies to sustain readiness:

1. Optimize initial learning.
2. Optimize prediction of skill retention for more effective scheduling of refresher training.
3. Reduce the rate of skill decay.

The first strategy follows from research on overlearning, which has demonstrated that the better soldiers perform immediately after training the better they will perform after a retention interval (Hagman & Rose, 1983; Hurlock & Montague, 1982; Wisher et al., 1999). Thus, without knowing or attempting to adjust forgetting rates or refresher training, one can be confident that soldiers will stay at a criterion level of performance longer if they have been given some degree of overtraining (Arthur et al., 1998; Lance et al., 1998; Schendel & Hagman, 1980, cited in Hagman & Rose, 1983). This is simply a consequence of the nature of the forgetting curve, which declines in a predictable fashion from whatever initial performance level soldiers have achieved. The value of overlearning derives from the finding that even individuals who perform at a level of 100% accuracy or the minimum performance time for a task still benefit from further training, even though this is not evident in their training performance (Driskell et al., 1992). Thus, an individual who is trained beyond the level of perfect performance will exhibit slower forgetting and better levels of performance over time than an individual trained just to the level of perfect performance.

Overtraining can be performed all at once during the initial training session or spread out over time in the form of refresher training sessions to achieve the same effect. Schendel and Hagman (1982) directly compared the effects of overtraining and refresher training on retention of skill in disassembly/assembly of the M60 machinegun. The overtraining group was trained to criterion then received 100% initial overtraining, whereas the refresher group was trained to criterion then received the same amount of additional training midway through the 8-week retention interval. Schendel and Hagman (1983) found that the refresher and overtraining groups performed equally well on retention tests after the 8-week period. Thus, the total amount of training determined retention performance, regardless of the schedule according to which the training was given. Given that overtraining is as effective as refresher training, it is a technique that can reduce costs associated with bringing together equipment, personnel, and training staff. Military personnel and commanders, however, may question the value of overtraining because it appears counterintuitive that continued training after achieving a criterion level of performance provides additional benefits (Schendel & Hagman, 1982). This technique can seem wasteful even though it is actually a more effective use of limited resources.

The benefits of overtraining can be obtained by techniques other than just repetitive practice. Various methods of training can enhance the speed and effectiveness of training, depending on the nature of the tasks being training. Cognitive-oriented training techniques, for example, can lead to superior memory performance for task knowledge, whereas experiential or "learn-by-doing" techniques can improve learning of procedural skills (Healy, 1997).

It is also possible to improve overall unit training performance by applying selection techniques to identify individuals exhibiting good aptitude for the kinds of skills to be trained. Selection has traditionally been a component of military training and job placement, based on the premise that selection of individuals with appropriate or superior skills reduces training costs and increases overall effectiveness (Levine & Wildzunas, 1999).

Given that skill loss will occur even if military personnel are overtrained, researchers have devoted a great deal of effort to a second strategy of determining means to optimize the schedule of refresher training. This is needed so that military personnel will receive training when needed to prevent them from falling below a criterion level of performance. One way to accomplish this is by a Readiness Reporting System (RRS) in which units report unit readiness in terms of ability to perform required functions and estimates of the training needed (Harvey, 1997). An RRS, however, is typically based on the subjective estimates of each unit commander and there are no checks on the accuracy of these estimates or that commanders use the same factors as a basis for their judgments.

The UDA (Rose et al., 1985a; 1985b) is the most comprehensive attempt to develop an objective method of predicting skill retention. The projected role of the UDA is to accurately inform unit commanders of their unit performance levels over time so that refresher training can be scheduled in an effective manner (Wisher et al., 1999). The value of the UDA compared to other approaches is that the UDA has been scaled to actual retention intervals. That is, the UDA provides predictions of the effects of retention interval in units of real time so that unit commanders can easily determine the predicted level of unit performance at any interval up to one year. Other approaches have not been refined to this point and, as yet, can offer only relative estimates of skill retention.

The third strategy is to reduce the rate at which skill decay. Some researchers (e.g., Healy, 1997; Sterling & Quinkert, 1998) have recommended development of computer-based training programs and simulations as a means of slowing skill loss. Such training devices, when deployed to units, allow almost continuous opportunities for practice. A potential drawback of such training devices, aside from the cost of their widespread distribution, is that they may be unable to provide the range of realistic scenarios and training practices needed to give military personnel effective practice (Brown, 1992, cited in Sterling & Quinkert, 1998). Advances in computer technology are making computer-based training more effective but the applicability of this technique depends on the particular task under consideration. Marx's (1986) Relapse Prevention Model (Section 3.4.2) could be a valuable tool to provide individuals with techniques to reduce forgetting and skill loss. This model teaches people how to recognize situations and behaviors that contribute to forgetting and how to combat these factors. The model, however, is directed at retention of managerial skills and it is unclear how it applies to other cognitive or procedural tasks.

The US Army Europe (USAREUR) developed a strategy to sustain combat readiness while deployed in Bosnia for a peacekeeping mission that illustrates these three strategies to some degree (see Blankmeyer, 1998). The first step of the USAREUR strategy was to complete rigorous combat and peacekeeping training prior to deployment to Bosnia. The home training seems to have served as overtraining, which "inoculated" units against excessive skill loss. The second step was to perform refresher training for warfighting skills during deployment. This was often difficult due to limited access to training equipment and locations. Subordinate commanders were given substantial freedom to develop training programs to make best use of limited resources and tailored to the particular refresher training needs of their units. Units made extensive use of simulators and other training devices that could be transported to the field, which helped overcome some limitations imposed by the politically sensitive nature of the peacekeeping mission. Finally, upon return from Bosnia, units engaged in retraining in combat skills and were able to achieve combat readiness in somewhat less time than anticipated.

6. Discussion

6.1 Lessons Learned

1. Many factors affect skill retention. We have documented a number of these factors (Section 3.1) but, in fact, there are more factors than can reasonably be accommodated in either this literature review or a model for predicting skill retention. Thus, a first step in predicting skill retention must always be determining the subset of factors to include in the model to provide maximum predictive power.

   This, however, is not necessarily a straightforward process. If we could rank order factors by the degree of their effect on skill retention, we would have a means to select the most influential factors. Only a few studies, however, have so far attempted to quantify and rank the effects of factors on skill retention (Arthur et al., 1998; Farr, 1987, cited in Arthur et al., 1998). These studies have been limited by the paucity of data. Arthur et al. (1998), for example, were unable to generate skill retention curves to test the validity of the negatively accelerated forgetting function suggested by prior reviews. Furthermore, they were unable to perform analyses of the moderator effects of factors because effect sizes and retention intervals were not normally distributed.

   Perhaps a more fundamental obstacle to ranking factors in terms of their effects on skill retention is the likelihood - indeed the virtual certainty - that factors interact in complex ways. Numerous studies have demonstrated interaction effects between various classes of task, training, and individual factors (see e.g., Arthur et al., 1998; Driskell et al., 1992; Rose et al., 1985b). Depending on the nature of these interactions, retention of some skills may be best predicted by one set of factors and retention of other skills by a different set of factors. It may be necessary to develop a functional classification of military tasks and study the relative effects of factors for each category. It may be, for example, that basic procedural skills, specialized skills, and command skills will be affected differently by factors and, hence, differentially predicted by models of skill retention. It is, at this point, an open question whether all kinds of skills can be accurately predicted by a single model. The most comprehensive model available, the UDA model (Rose et al., 1985a, 1985b), was developed and validated for a fairly restricted range of specialized MOS skills.

2. Skill loss follows a predictable course. Despite the effects of a large number of factors, skilled performance declines according to a power function of time (Anderson, 1995; Childs & Spears, 1986; Wixted & Ebbesen, 1991). Thus, any given factor influences the rate at which performance declines and the asymptote level at which performance settles but does not dramatically alter the basic nature of forgetting. In all cases, most skill loss occurs soon after training and the rate of forgetting continually decreases.

   It is important to define skills clearly and accurately in order to predict retention. Most tasks involve sequences or sets of distinct learned skills. If these are not distinguished, retention may appear to follow a complex function that deviates from the traditional power function. Amalgamating skills will necessarily increase the error in prediction of retention.

3. Models of skill retention tend to consider only factors associated with the task. We identified four classes of factors relevant to skill retention (Section 3.1):

- **Task factors**, which pertain to the nature of the task or skill to be acquired; e.g., complexity.
- **Training factors**, which pertain to the types of training manipulations employed in initial learning; e.g., length, style.
- **Learner factors**, which pertain to the individual differences and factors that affect learning and retention; e.g., aptitude, experience.
- **Retention interval factors**, which pertain to the events and manipulations occurring between training and performance; e.g., length, opportunity for practice.

These classes reflect pragmatic rather than theoretical distinctions and the choice of task factors as a basis for predicting skill retention likewise reflects practical concerns. Task factors are, in general, easier to assess than other classes of factors and, as such, less expensive in time, money, and other resources to use. Task factors are stable as long as the task itself does not change and predictions will apply equally to all individuals and training groups performing the task. Training, learner, and retention interval factors are dependent on the particular individuals receiving and/or conducting training. Thus, these factors must be assessed for each individual and each training group to be used to predict skill retention. This dramatically increases the effort involved in using these factors as predictors.

Although task factors are clearly very convenient, it is not clear that they offer the best predictors of skill retention. Factors such as the degree of overlearning (Hagman & Rose, 1983; Lance et al., 1998; Schendel & Hagman, 1980, cited in Hagman & Rose, 1983), opportunity to practice (Blankmeyer, 1998; Ford et al., 1992; Landry & Campbell, 1997), similarity of training and performance environments (Healy et al., 1992; Marmie & Healy, 1995), and possibly individual aptitude (Earles & Ree, 1992; Hurlock & Montague, 1982) have strong effects on skill retention. To achieve the best possible prediction, a model should include these factors.

4. Subjective models of skill retention have the potential to lead to usable models for predicting skill retention but require further development. A long tradition in cognitive psychology supports the power and utility of human meta-cognitive abilities. Moreover, a number of studies (Gordon, 1991; Schendel & Hagman, 1982; Wisher et al., 1991) indicate that people's self-assessments can be highly predictive of retention and need for refresher training.

The research literature, however, is not uniformly supportive. Some studies suggest that people's self-assessments tend to be biased (e.g., Schendel & Hagman, 1982). Other studies have found self-assessments of skill retention less accurate than assessments by observers (Wisher et al., 1991). Thus, it is not clear that self-assessment can serve as the basis for prediction of military skill retention at the present time. Further study and development is needed to validate this approach and devise reliable methods to obtain accurate self-assessments of knowledge and need for training.

There are a number of advantages to subjective methods. They are relatively easy and inexpensive to obtain, involving minimal training and no special equipment. These techniques also afford very flexible means to monitor and remediate skill loss. Using subjective techniques, individuals could potentially customize a schedule of refresher training that optimizes retention of skills for each individual in a unit. These advantages, however, are limited by the susceptibility of subjective techniques to malingering. Without adequate safeguards, individuals can avoid needed training simply by claiming to have better retention than they actually do. Likewise, individuals could engage in an excess of unnecessary training by claiming to need it. These concerns can lead to a general mistrust of subjective methods among unit leaders and trainers, which would likely reduce their effectiveness further.

5. Qualitative approaches to predicting skill retention do not seem well suited to predicting retention of military skills. These tend to be the least developed kinds of models, which leads to vague predictions of retention. These models also tend to be more prescriptive than predictive (see Marx, 1986). That is, they are designed more to offer techniques and strategies to reduce skill loss than means to predict the rate of skill loss. Although such techniques are undoubtedly valuable, they do not address the central concern of this literature review.

6. The UDA is the model found to be usable at the present time to predict retention of military skills. Not only have ARI researchers identified a set of predictive factors, they have determined the empirical relationships of each factor to skill retention to quantify their effect sizes (Rose et al., 1985a). These have been scaled so that ratings can be used to produce estimates of retention in units of real time.

   The UDA model is easy to use and requires few resources in either time or money. Some training in the use of the UDA is necessary but Radtke and Shettel's (1985) study indicates that this training does not need to be intense or prolonged. Another advantage of the UDA is that it applies to a range of military skills. The model was developed on the basis of data gathered from U.S. Army populations performing various MOS tasks. The model was also validated with respect to a similar set of data (Rose et al., 1985b). The result is a tool that can be distributed to commanders and trainers and employed with minimal training. No other model surveyed approaches this level of development.

   The major weakness of the UDA model is that ARI researchers developed and validated the model with respect to a somewhat limited range of tasks. Although these tasks are representative of military activities, they were selected from U.S. Army MOS tasks and, thus, represent specialized skills. These specialized skills tend to be highly procedural and composed of discrete steps. This is potentially important because the nature of the task (e.g., discrete versus continuous, motor versus cognitive, etc.) can affect the rate of skill loss (Arthur et al., 1998; Hurlock & Montague, 1982; Schendel & Hagman, 1991). The military trains individuals in a wide range of tasks, including basic tasks such as small arms proficiency and highly cognitive tasks such as decision making and command. It is unclear how well the UDA model applies to these kinds of tasks and we found no study directly examining this issue.

   Another problem is that the UDA model has received only a small amount of empirical support. Many studies claim to report evidence of the validity of the UDA model (Macpherson, Patterson, & Mirabella., 1989; Sabol, Chapell, & Meiers, 1990; Wisher et al., 1991; Wisher, Sabol, & Ozkaptan, 1996; see Wisher, Sabol, & Ellis, 1999) but these do not, in fact, compare predictions of the UDA to actual retention.

   Although well developed, the UDA model requires more extensive validation based on independent data sets covering a comprehensive range of military tasks. Empirical studies in this regard will determine the applicability of the model to basic, specialized, and command skills.

7. Other quantitative approaches to predicting skill retention are based on the same logic as the UDA model but are not as well developed. A number of studies have attempted to determine the function(s) relating one or more factors to skill retention (see Arthur et al., 1998). Any factor could potentially be related to retention in this way; the trick is to find the most predictive and usable factors for prediction. Thus, quantitative approaches do not differ in principle from the UDA model.

   The main value of other quantitative models is to suggest useful factors that may be considered as a means to augment the UDA model. There is no guarantee that adding more factors to the UDA model will yield dramatically better predictions but, as mentioned, many factors affect skill retention. In particular, it may be worth considering training and individual factors in addition to task factors, despite the expense and difficulty of assessing these factors. Some quantitative approaches also suggest factors not traditionally considered in modeling skill retention, such as the amount of resources expended on training (Sulzen, 1997), as a way to improve predictive power.

8. Changes in technology and the military environment will complicate future training requirements. We expect military personnel will train in a much wider range of skills in the future due to changes in technology and the military environment. Computers and computerized equipment are taking a more prominent place in the military and this increases the need for digital skills (Richard, 1997; Salter & Black, 1998). The military is also being called upon to perform more non-traditional missions, often broadly categorized as MOOTW. These missions entail specialized policing and support skills outside of combat skills (Taylor, 1997). Overall, military personnel will likely train in more, and more diverse, skills than in the past. This in turn, complicates the problem of maintaining readiness in all trained skills.

   Although training will become more challenging in the future, advances in technology and training methods should aid sustainment. Better training techniques can allow military personnel to achieve higher levels of initial skill acquisition, which translates into better retention over time (e.g., Brown et al., 1998). The use of mobile training devices, including simulators and computerized trainers, can allow for more frequent and flexible practice and refresher training in the field. The placement of such devices heightens the need for an accurate tool to predict skill loss in order to effectively schedule practice and refresher training.

6.2 Recommendations

1. Validate the UDA for the CF. Given the limited direct empirical support for the UDA, it is necessary to conduct further studies with independent data to determine how effective it is as a predictor of skill retention. Validation studies are needed to ensure that the UDA can accurately predict retention for basic and cognitive tasks that differ from the MOS tasks used in developing the UDA. These studies will also determine whether the UDA predicts CF tasks to an acceptable level of accuracy so that predictions are useful in scheduling refresher training.

2. Should validation studies indicate that the UDA is not sufficiently predictive, conduct research to determine what factors can be incorporated to increase the accuracy of predictions. We have identified four potential factors (degree of overlearning, opportunity to practice, similarity of training and performance environments, and individual aptitude) but it is unclear to what extent these factors are complementary to the task factors assessed by the UDA.

3. Develop self-assessment tools. Subjective techniques offer potentially practical and accurate means to predict skill retention. These techniques, however, must be carefully developed and validated to develop usable tools to aid scheduling of refresher training.

4. Determine the applicability of the Relapse Prevention Model to command, administrative, and other related tasks. Although the Relapse Prevention Model is unlikely to be broadly applicable, it may be useful in predicting and/or remediating skill loss in certain areas. Many command skills in the CF could share common features with the managerial skills for which the model was developed.

5. Conduct studies to derive empirical retention curves for critical tasks. Deriving empirical retention curves requires a large effort and so this technique is not broadly applicable. Nevertheless, empirical retention curves may be the most accurate tool for predicting skill loss

available. Consequently, where the importance of a task warrants the effort, researchers should develop retention curves.

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Annex A

Individual Battle Task Example

Annex A:
Individual Battle Task Example

This example was taken from B-GL-304-002/PT-Z04, Individual Battle Task Standards (IBTS), Training for War, Volume 2.

Individual Battle Task Standard - Fire the C7/C8

1. Battle Task. Fire the C7/C8

2. Conditions:

   a. Given:

      (1) C7/C8 as per EIS,

      (2) ammunition,

      (3) fighting order,

      (4) fire control orders,

      (5) suitable firing area.

   b. Denied: assistance.

3. Standards. The soldier must achieve the standards in accordance with reference A, prior to deploying on operation:

   a. Pass weapon handling tests.

   b. Successfully achieve the standard at Stage three as follows:

      (1) infantry - zero and pass PWT level three and night supplement,

      (2) others - zero and pass PWT level two and night supplement.

c. Adopt firing positions.

d. Engage a figure 11 target with ten rounds in TOPP high from 200 m in the prone position and achieve (5) hits.

e. TsOET. The following is the TsOET to be achieved yearly for this Battle Task:

(1) pass the weapon handling tests;

(2) adopt firing positions;

(3) group, zero and pass Stage Three, PWT level one in accordance with reference A, less the standing unsupported practice.

4. Supporting Task. The successful completion of the following supporting tasks necessary for the attainment of the standard:

a. identifying and handling small arms ammunition;

b. holding, aiming and applying the principles of marksmanship;

c. maintain the C7/C8 to include:

(1) basic stripping and assembly,

(2) cleaning.

5. Resources. The following resources are required to meet thistask standard:

a. 222 Rds of 5.56mm ball for Stage Three level three PWT with night supplement;

b. 133 Rds of 5.56mm ball for Stage Three, level two PWT with night supplement;

c. 35 Rds of 5.56mm ball for Stage Three, level one PWT;

d. 10 Rds of 5.56mm ball for TOPP High shoot;

e. 30 Rds of 5.56mm ball for zeroing IAW practice 4, Annex A of reference A;

f. 40 Rds of 5.56mm ball for grouping IAW Stage one, practice two or three (range dependent) of reference A;

g. appropriate cleaning and range materials.

6. Award. Completion of the TsOET for this Battle Task and achieving one of the following shooting levels will qualify as successful completion of the TsOET for WARRIOR programme purposes. (Padres are not reqr to fire the PWT to be awarded a badge, but must complete the handling tests) :

a. 51 of 60 points: Gold;

b. 47 of 60 points: Silver;

c. 42 of 60 points: Bronze.

7. References. The following are the principal references to be used for this battle task:

a. B-GL-318-006/PT-004 - Shoot to Live,

b. B-GL-317-018/PT-001 - Weapons, Volume 18, Rifle 5.56mm C7 and Carbine 5.56mm C8.

Annex B

Infantry Battle Task Example

Annex B:
Infantry Battle Task Example

This example was taken from Infantry Battle Task Standards, B-GL-383-002/FP-015 (INTERIM).

Infantry Battle Task Standard 4001 B/C - ATTACK

ELEMENT: SECT / PL

CONDITIONS:

The section / platoon commander reacts to effective enemy fire, and conducts a quick attack. The enemy has been in position for 24 hours and may have prepared positions with mines and wire. Both friendly and enemy forces have indirect fire capabilities. When a well-prepared enemy defence must be defeated, a deliberate attack may be required, with emphasis on planning and preparation at the expense of speed and time. In this case, the enemy location may or may not be known, and the enemy may or may not have engaged the friendly force.

TASK STANDARD:

The section / platoon successfully conducts a quick or deliberate attack. The section / platoon captures, destroys or forces the withdrawal of the enemy IAW the assigned mission.

TASKS AND STANDARDS

1. The section takes action IAW Section Battle Drill Two, 'Reaction to Effective Enemy Fire,' and IAW Section Battle Drill Three, 'Locates the Enemy.'
2. Elements not in contact help to determine essential enemy information:
   A. location of, and covered and concealed routes into enemy's flanks and rear
   B. possible locations of obstacles and supporting enemy elements
   C. all information on the enemy and terrain is reported to the section / platoon commander and relayed to the higher HQ.
3. If the section is operating independently, the section commander decides if the section has sufficient combat power to destroy the enemy, or if the section should dig in, bypass, or withdraw.
4. If the section is part of a platoon, the platoon commander takes action IAW Platoon Battle Drill One, 'Reaction to Section coming under Effective Enemy Fire,' and moves forward to assess the situation and takes over, or orders the section commander to attack.
5. If the section is operating independently and has sufficient combat power to destroy the enemy, or on order from the platoon commander to attack, the section commander completes a combat estimate, issues battle orders, and takes immediate action IAW Section Battle Drills:
   A. Battle Drill Four - 'Winning the Fire Fight'
   B. Battle Drill Five - 'Approach'
   C. Battle Drill Six - 'The Assault'
   D. Battle Drill Seven - 'Consolidation.'

6. Additional fire support for the section attack may be obtained from the platoon. OR
7. If the platoon commander decides to conduct a platoon attack, he completes a combat estimate, issues battle orders, and takes action IAW Platoon Battle Drills:
   A. Battle Drill Two - 'The Hasty Attack'
   B. Battle Drill Three - 'Consolidation.'
8. The section / platoon exploits any opportunity that may exist, but does not proceed beyond the limit of exploitation.
9. The section / platoon commander reports the situation to higher HQ and continues the mission.

Annex C

Battle Group Task Example

Annex C:
Battle Group Task Example

This example was taken from Battle Group Battle Task Standards, B-GL-383-002/PT-003.

BATTLE GROUP BTS 2001 F - EMPLOY INDIRECT FIRE SUPPORT

ELEMENT: BATTLE GROUP

CONDITIONS

The BG is operating as part of the bde gp. Both en and friendly forces have indirect fire and CAS aval.

TASK STANDARDS

The BG comd and BC, and cbt tm comds and FOOs plan and execute indirect fire that supports the comd's plan and covers likely en approaches and key terrain. Friendly fire does not cause unnecessary friendly casualties.

BATTLEGROUP TASKS

1. The BG comd, BC and FC (if aval), and cbt tm comds and FOOs make a tentative fire plan:
   a. develop a fire sp plan in concert with the bde gp comd's plans, guidance and intent
   b. integrate the BC, FOOs and FCs (if available) to ensure they are in position to execute their assigned tasks
   c. augment the fire of the bde gp's fire sp plan IAW the bde gp comd's guidance to ensure indirect fire is planned in depth
   d. establish recorded targets on likely en approaches and positions.
2. The BG comd and BC, and cbt tm comds and FOOs conduct a recce and plan targets:
   a. identify en positions and likely positions
   b. identify vital ground and key terrain
   c. target en approaches
   d. establish DFs and FPFs
   e. approve fire plan and distribute down to pl/tp comds.
3. Execute fire sp:
   a. all available supporting direct and indirect fire is synchronized and executed in a timely manner and accomplishes the desired result IAW the fire plan
   b. fire hits critical/vulnerable area of en formations or positions
   c. friendly fire stops or slows en movement
   d. friendly fire sufficiently suppresses en fire
   e. the volume of fire is appropriate for the task
   f. friendly fire causes no unnecessary friendly casualties
   g. appropriate arty control measures are used to limit friendly casualties
   h. friendly forces are not silhouetted by friendly smoke
   i. fire sp priorities are adjusted as the battle progresses
   j. the BG comd and BC effectively employ CAS, attack helicopters and naval gunfire, when allocated, and consider the en air defence threat
   k. engagement results are reported at the conclusion of each fire msn
   l. friendly force locations are reported to the DS battery CP.

Annex C:
Battle Group Task Example

DOCUMENT CONTROL DATA

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Skill Retention

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The Canadian Forces (CF) trains in a wide variety of skills. For reasons of efficiency and economy, it is important to conduct no more refresher training than is necessary to keep performance at the desired skill level. This work surveyed the scientific and technical literature for models of skill fading and tools for determining when refresher training is required. In particular, the literature review investigated models for predicting skill retention relevant to the military domain. Subjective approaches, qualitative approaches, and quantitative have been used to model skill retention. Currently the U.S. Army Research Institute's Users' Decision Aid (UDA) model is the most advanced model. The UDA is one of few approaches for which empirical research has been done to assess its applicability and practicality. The UDA has been demonstrated to be relatively easy to administer, although some training is needed to perform the ratings correctly and reliably. The UDA itself is low-cost and requires no special equipment. The UDA, however, has received empirical validation from just one study that reports a comparison between UDA predictions and actual retention data. The literature review identifies a set of lessons learned and discusses five specific recommendations.

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Training, skilled performance, skill retention